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TIMBUCTOO: ITS COMMERCE AND LIFE.

An old Soudanese chronicler has excellently summed up all the reasons for the commercial grandeur of Timbuctoo in this simple image: "It is the meeting place of those who travel in a pirogue and those who make their way on camel's back." The pirogue represents the south of Timbuctoo—the Soudan, that is to say, fertility and richness in everything. The camel has a more complicated signification, since it typifies the whole of Northern Africa: in the first place, the Sahara, that is to say, sterility, but also the valuable mines of rock salt; then the Arabian countries—Morocco, Algeria, Tuat and Tripoli; and finally Europe, through the depots of merchandise that the latter has installed in the ports of the states of Barbary.

The north and south required an intermedium for their exchanges and an entrepot for their productions, and this was the role for Timbuctoo, which serves as a bond of union between the Berber and Arabian and the negro world. A unique situation wonderfully facilitated such a task. Placed at the exit of the labyrinth of sea arms, canals, and lakes, and at the spot where the eastern and western Niger trace their opposite courses, it offered to the south an easy point of concentration, touched at in every part by railways. The Soudan was capable of bringing its products together here in large quantities, and, at the same time, of satisfying all its northern customers. So Timbuctoo soon became the common terminus of all the routes of the Sahara. It is, therefore, a port with full laden docks upon the shores of an opulent continent, and in front of it spreads out the sea of sand upon which go and come those commercial fleets of the desert—the caravans.

The commerce of the north and the organization of the caravans depend upon the Moorish and Arabian tribes that live upon the confines of the Sahara, and that devote themselves to the breeding of camels, which they hire to the traders of Barbary.

Morocco has become the principal customer of Timbuctoo, as being the country nearest the Soudan, and so Souera, Marrakech, Fez and Tafilalet are the starting points of its caravans. In the second place comes Algeria, the relations of which, however, are not direct, but take place through the intermedium of Tuat. So too, Tunis and Tripoli trade through the intermedium of Ghadames.

Upon leaving the coast country, the caravans take the following load: European fabrics, indigo-blue cottonades, white calico, silks, firearms, powder, cutlery, paper, scissors, needles, mirrors, small pearls for embroidering, amber, coral, spices, sugar, tea, coffee, perfumes, tobacco, dates, ready made clothing, etc. Only half of the camels are thus loaded at the start, the caravan completing its freight at the middle of its route with salt, a product that is of the utmost importance to the Soudan.

The caravans procure this as follows: In the western Sahara there is a long depression that bears the name of El Djouff, and is merely a vast mine of rock salt, the exploitation of which is now carried on at Taoudenni. The various contractors of Taoudenni mark upon thin slabs (or "bars," as they are called) as they come from the mine one of the following signs or trade marks as it were: A, O, I, +, —, etc. At Timbuctoo, before being sent across the negro country, the slab of salt is the object of a true toilet. By means of black paint it is ornamented with geometrical designs, and the venerated name of some living scherif, of a saint, or of some great person is inscribed upon both surfaces. It is then surrounded with thongs of undressed leather, in order to keep the pieces together in case of a breakage. The thickest and whitest slabs are the ones most in demand, those that bear a trace of reddish silicates being of in-

LADY OF TIMBUCTOO UPON HER TERRACE.

VIEW OF TIMBUCTOO FROM THE POOLS.

ferior quality. With the prospect of such a voyage as it has to make, the advantage of salt in slabs over our salt in powder is easily seen. Agglomerated and as hard as stone, it is not attacked by humidity, and, on another hand, losses by theft, so easy with salt in bags, are avoided.

Having completed its load at Taoudenni and paid one or more tolls to the Touaregs who have custody of the routes, the caravan finally reaches Timbuctoo, before the walls of which it encamps.

While the traders who accompany the caravan take lodgings in the city, the camel drivers procure bed and board in the outskirts. In the very near vicinity there are large pools for watering the camels.

The number and size of the caravans are intimately connected with the tranquility of the Sahara on the one hand and the prosperity of the Soudan on the other. The large caravans generally comprise from 600 to 1,000 camels and from 300 to 500 men, inclusive of traders, and each represents a value of from $120,000 to $200,000.

As the Saharian camel cannot withstand the climate of the plains of the south, the caravans never go beyond Timbuctoo. In order to do the counterpart of Northern Africa, the Soudan sends its flotillas to their stopping place. These start principally from Dienné, Sansanding, Dia, Korienze, Sa, Dire, Sarefere and Dare-Salam. The countries of the bend of the Niger (Mossi, Miniankola, Dafina, etc.) organize convoys of oxen, asses or porters for reaching the nearest of the fluvial ports that we have just mentioned. Ascending to the height of the Nile, the flotillas land at Kabara, Dai or Kourioume, which for them play the part that the environs of Abaradion do for the caravans. A provisional unloading is effected and the boatmen take up their quarters here. Their place of landing is at Timbuctoo or to the southwest, a short distance from the grand Mosque. Seen from this point, Timbuctoo appears under a particularly pleasing aspect, with bouquets of verdure and elegant palm trees in the foreground, and recalls the oasis that it was in its early days.

Upon this western border of the town a string of pools has been formed through subterranean infiltrations. The deepest of these has been carefully fenced in and serves as a cistern. It is here that the population obtains its drinking water. A guardian lives at the entrance and prevents people from using the water for washing or bathing. The other pools serve for washing or as watering places for the camels.

Like the load of the caravans, the cargo of the flotillas comprises two very distinct parts. First, products for food and consumption designed for the nomad tribes and the towns of the Sahara and for Timbuctoo itself; and second, products especially designed for the traders of Morocco, Tuat and Ghadames.

The so dissimilar shipments of the north and south being known, the nature of the Timbuctooyan commerce now appears in all its simplicity. It is a double go and come of the caravans of the Sahara and the flotillas of the Niger. Between two regions so different as the Sahara and the Soudan, an enormous transshipment is necessary, and the place of this is Timbuctoo. It is a provisional entrepot upon the limit of the plains of sand and of the copiously irrigated valleys—a town of stores and docks, and to such a point that no Timbuctooyan possesses either a single camel or a single boat.

What, then, is the role of the population? Not being traders, properly so called, or importers or exporters, the Timbuctooyans are bonders, brokers and landlords. "The guest is a present from God," says a maxim that is highly appreciated at Timbuctoo, where there are no caravansaries. During the first three days the inhabitant offers the foreign merchant board and lodging gratuitously. After this, as he owns several houses, he lets one to his guest. These structures are quite roomy and may consequently be used as stores as well as dwellings. The role of the "diatigui" or lessor does not end here. He keeps the stranger informed as to the state of the market, as to the abundance or scarcity of the product that he has come to buy or sell, and as to the standing of the customer who presents himself, and leads and guides his guest in his purchases.

The middleman is almost a necessity. Timbuctoo, indeed, has three market places, but only commodities for daily consumption are found therein. The true commercial operations are not transacted there, but are concluded in the city houses, which are indicated to the stranger by no sign nor inscription.

Along with the official brokers, there is one called the "taifa," who makes a specialty of certain products, such as salt, gold, fabrics, etc., and who goes from house to house offering his services and showing samples and giving prices. There are at least a hundred of these specialists, who follow the profession from father to son. But, upon the whole, every one is a broker in Timbuctoo, even the woman and child.

Like speculation, fraud and adulterations have long been known in Timbuctoo, such, for example, as the use of false weights and measures, the mixture of copper with virgin gold and silver, the weighting of gold dust with various substances, the watering of milk, etc. For this reason, the commercial houses of Morocco, Tuat, Ghadames and Dienne have freed themselves from the onerous intermedium of the Timbuctooyan, and, for a long time, have owned their own houses. Here they install some relative or confidential slave, whose accounts are verified annually.

It would be an error to belive that Timbuctoo was ever a very populous town. From the area that it formerly occupied, it is probable that, in the time of its splendor, it had from forty to fifty thousand inhabitants. At present, it has but eight thousand inhabitants, or, more properly speaking, traders, since the population of Timbuctoo lives on nothing but its commerce.

In the single month of January, 1895, statistics showed a business of $92,000, but this is said to represent only a third of the actual traffic, and for the following reason: For want of a staff of inspectors, it has not as yet been possible to make any serious attempt to obtain accurate data. The captain of the ports of Timbuctoo has not even an interpreter at his disposal. It is necessary to be content with the voluntary affidavits made by the traders to the negro commissaries of police of Timbuctoo and Kabara, and by these to the military authorities. Now, the African trader is no fonder of making every one acquainted with his business than the European. To give but a single fact: Not a fraction of an ounce of gold, either imported or exported, was declared at the period above mentioned.

Timbuctoo, however, was not only a place of great commerce, for it likewise represented, for entire Western Africa, the great town of pleasure. After gold, ivory and ostrich feathers, one of the principal attractions of Timbuctoo for the people of the north was certainly the free and easy manners of the Soudan. This fact becomes apparent not only from the stories told by the Timbuctooyans, black and white, of today, but from the narratives of the old Arabian travelers.

Leo Africanus is content to say: "The inhabitants of Timbuctoo are all of an agreeable nature, and in most

CAMELS AT THE WATERING PLACE.

THE COMMISSARY OF POLICE AT THE MARKET.

VIEW OF THE TERRACES.

cases go off, to an advanced hour of the night, dancing in the city."

Leo was writing for the Vatican, and this explains his reserve. Ibn Batouta (1350), who is more explicit, gives a full account of the licentiousness of the Timbuctooyans of his time and notes their customs with indignation. Without dwelling further upon this, let us speak of the ladies of Timbuctoo, that is, those who

MOSSI TRADERS.

belong to the great and ancient families of the city. In consequence of continual mixtures with the Berber and Arab races, their features, although black, are refined. The face is regular and of the Aryan rather than of the negro type, with superb, large, intelligent and soft eyes. To these natural gifts they add the resources of coquetry and Arabian or negro elegance, ornamenting their nails with henna and brightening their eyes with applications of antimony to the lids

THE GOLD DEALER.

and eyebrows. The forehead is prettily decorated with strings of pearls, Moorish designs or gold coins in garlands. From the ears hang golden pendants, and around the throat are worn ample collars of amber or coral that have a picturesque effect upon the bronze skin. Finally, they have the art of draping themselves with much taste in the fabrics of all kinds that are met with in Timbuctoo. They like to play the great lady, and confide all the cares of the household to male or female slaves. They employ their leisure time in reading or playing a small violin whose only string is made of camel's hair, or in making calls, or in receiving visits, or in smoking the pipe.

Besides these, there are a very large number of women who belong to the demi-monde and who imitate the former in everything.

As business often affords leisure, the foreign trader, in order to amuse himself, invites his friends to a noon or evening entertainment, at which are served a fat sheep, pigeons, couscouss, dates, kola nuts, wheat cakes or honeycomb. The beverage is tea and sometimes coffee. Marabouts, scholarly story tellers, to whom some sort of present is made, and who are likewise invited guests, charm the reunion with tales of the olden time. Each guest, too, narrates the events and history of the country whence he comes. It is thus that many things are known at Timbuctoo, not only about what is going on in Morocco, Tripoli or at Lake Tchad, but even the news of Europe.

For the foregoing particulars and our illustrations, we are indebted to L'Illustration.

Leo XIII has just received the present of an American typewriting machine inlaid with pearl and silver, with the Papal coat of arms emblazoned on it.

ON PERIODICITY OF GOOD AND BAD SEASONS.*

I FEEL some reluctance in coming forward to-night, with the result of my investigations into the periodicity of good and bad seasons—floods and droughts, if you will—because they must come to you as a surprise, and they will make a claim on your confidence which at first sight you will probably not be disposed to grant. For myself I know that some years ago, if any one had come to me stating that it was possible to forecast the seasons many years in advance, I should have received the statement with incredulity. The difficulty in getting the facts together is very great. I have had to ask from history records of passing phenomena which it has been the habit of the historian to neglect; however, there will be before you a mass of evidence in support of my proposition, that there is a periodicity in weather. The weak point in the evidence is that history has not kept a regular and continuous account of droughts, but only recorded them when they became very prominent. The strong point is that all the data that history does give us is in favor of the nineteen years' cycle.

And it may be explained that the word drought is not used here in the sense in which it is often used in England and elsewhere, that is, to signify a period of a few days or weeks in which not a drop of rain falls; but it is used to signify a period of months or years during which little rain falls, and the country gets burnt up, grass and water disappear, crops become worthless and sheep and cattle die.

Drought is, however, not wholly made by a deficiency of rainfall. Its most important factors are great heat and drying winds. As an illustration we may look to the year 1895; in the latter part of winter and in spring there were many falls of rain, which would have made grass in ordinary seasons, although there was not as much as usual, but it had no sooner fallen than a dry northwest wind and burning sun dried it all up. This great and burning heat was a well known feature in historical droughts, and some authorities say that the fable of Phaeton driving the chariot of the sun so close to the earth that he set it on fire is a poetical setting of an actual experience in Greece when the sun became so powerful that the heat was almost beyond endurance.

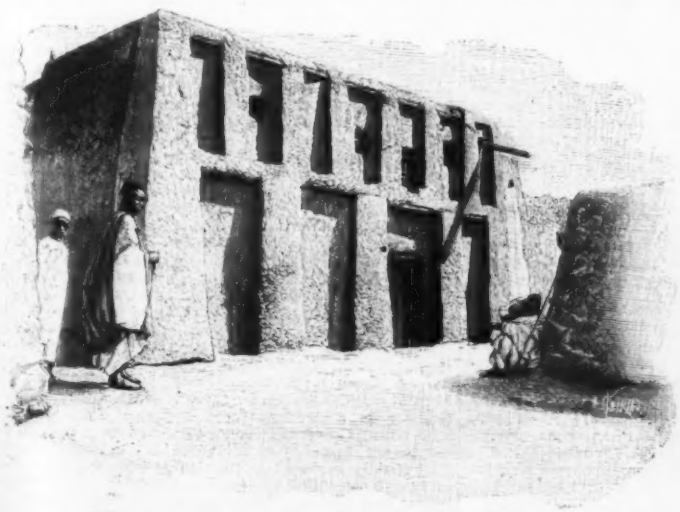
Before 1895 all the diagrams I used had been made to show quantities of the various elements, and their relation in time, with a view to seeing if there was any periodicity. Recently it occurred to me that it would be useful to have a diagram in which all the droughts, without regard to their intensity, should be placed in their order of time; not only was this desirable for seeing what the relation in time was, but it had become evident that it would be impossible to see the relation between our droughts and those in other countries, unless some such pictorial arrangement were made.

As a preliminary to making the diagram, the particulars of the weather in this colony from all sources, for every year of our history, were carefully examined, and the years simply classed as good or bad; that is, having sufficient or insufficient rainfall. A form was then prepared with a vertical space for each year, and across these a zero line was drawn to divide the good from the bad; and, beginning with 1895, I filled in for that year, and below the line, a convenient length of the column in red ink; the length was simply to catch the eye. Then for 1894, a good year, I filled in with black ink, above the line, a space equal to the red in the vertical space for 1894. The two years were thus contrasted simply as good and bad; the question of how good, or how bad, was purposely left out. The diagram was then completed, each year being treated in the same way back to 1788. It was at once apparent that a drought lasting from three to seven years was most regular in its occurrence. A vertical red line was then drawn between the first and second years of each of these dry periods, and it was found that the interval between two successive lines was regular and exactly nineteen years. The centers of another set of dry periods, more intense and relatively shorter than the first series, were found also to recur at intervals of nineteen years One of these droughts falls regularly between a pair of the more extensive droughts previously referred to.

In the whole period, from the foundation of the colony of New South Wales to the present year, i. e., 108 years, it is certainly very noteworthy that the most pronounced droughts recur with great regularity—that is, at every nineteen years throughout the 108 years. Indian droughts seem to have coincided with Australian ones in many instances.

The investigation had become interesting, and seemed to promise to show the exact year of the great

* Abridged from a paper read before the Royal Society of New South Wales, June 3, by H. C. Russell, C.M.G., F.R.S., and published in Nature.



HOUSE THAT BARTH INHABITED IN TIMBUCTOO.

HOUSE OF RENE CAILLIE AT TIMBUCTOO.

drought in this country, of which there was abundant evidence when the colonists landed here, both in the fact to the south of Sydney all the very large trees were dead, and between them were growing young trees; and the story of the blacks, who said that the river Hunter dried up; that all the great trees died, and most of the blacks; that those who survived had obtained drinking water from the mountain springs. I had long wanted to find out when this terrible drought in this colony took place, and the Indian record showed that the extensive drought had been repeated in 1769–70, which probably fixes the date; for the middle of the eighteenth century was very dry, generally, all over the world.

But, if we can carry the nineteen years' period in this way back beyond our history, the idea immediately presents itself, where are you going to draw the limit, is there any limit? It was evidently not a question for argument, but for proof or disproof by figures. Tables were prepared showing every date on which droughts of the first class recurred back to A. D. 1, and the same for droughts of the second class. I am not going to weary you by going through the list, but will give you the result. History says very little about droughts prior to A. D. 900. Between that date and this, a drought has, on the assumption, occurred at every nineteen years. In this interval of nine hundred and ninety-six years there have been fifty-two repetitions of drought, and the question is, What has history to say about its droughts? Well, it shows that these droughts have been repeated at various places on the earth on forty-four of the fifty-two dates; of these eight missing droughts, no less than six of them occurred between 1000 and 900 A. D., an interval when history was less complete on these matters. So far as I have gone, history furnishes us with seventy-eight droughts in different countries, all of which fit into the first series. During the same period, droughts of the second series recurred fifty-one times, and history records droughts, numbering eighty-nine, on thirty-six of these periods. Taking then the droughts history has recorded between A. D. 900 and 1896, we have seventy-eight of the first series and eighty-nine of the second, a total of one hundred and sixty-seven, out of two hundred and eight on record; but this is not all, for another class of drought, which is irregular in Australia, seems to be more definite and important in the northern hemisphere, and twenty-six more out of the two hundred and eight belong to this series, making up the number to one hundred and ninety-three out of the total of two hundred and eight.

In estimating the importance of these figures, it must be remembered that, before 1788, North and South America, Russia, China, Persia, Turkey, Austria and Australia, all subject to frequent drought, yet did not, however, furnish to the numbers quoted more than you could count on your fingers; and it may be fairly assumed that if we had these records, and especially if history had made a point of recording droughts, we should have had drought recorded on every recurrence of the nineteen years' cycle, of the two chief series; but I think the evidence that history furnishes one hundred and ninety-three recorded droughts, every one of which fits into the cycle, justifies us in assuming that the nineteen years' cycle has been running for a least one thousand years, and may be trusted to continue and justify forecasts based upon it for some time to come.

Having got so much from the study of droughts in the Christian era, it seemed desirable to see if there were any recorded in before Christ times. Records of twenty before Christ droughts were found, all of which, with one exception, fit into our nineteen years' cycle. If these dates are examined apart from their connection with Australian droughts, we find that the intervals between them are multiples of nineteen years, which shows that droughts then, as now, occurred in cycles of nineteen years, which is very strong evidence in favor of our theory, the more so when it is remembered that all the before Christ droughts I have been able to collect, except one, do fit in; they do not form a series of droughts selected for the purpose of supporting it; again, taking the dates given in the various works, the intervals between all these before Christ droughts and those in Australia are multiples of nineteen years.

If it be objected that chronologists have grave doubts about the accuracy of before Christ dates, I reply, that it is quite certain that chronologists did not arrange the dates to make them fit into an unknown cycle running among these droughts, or in connection with Australian droughts, the dates of which have been unknown until now. These dates are points in history, and the fact that they fall into a cycle of weather, itself supported by all the available drought dates of the last thousand years of history, is in strong confirmation of the accuracy of these before Christ dates.

These intervals in which our droughts are found repeated are surprising, but I am not unaware of the differences of opinion in regard to chronology, but take the dates as given, and it is remarkable how exactly they fit in. But there is another point of importance hidden in these dates, and probably you have not noticed it. Pharaoh's drought was predicted, and a Jew was made chief man under the king, and he was, doubtless, versed in much of the wisdom of the priests, and carried that wisdom to the Jewish priests, who did not forget it, as the figures make manifest, and if warning of such evils could be depended upon, it is not likely they would forget it. The figures show that Elijah's prediction was a repetition of Pharaoh's drought 49×19 years after it; also Elisha's prediction was nineteen years after Elijah's, and it is noteworthy that the drought in David's time, although it does not appear to have been predicted, was 19×36 after Pharaoh's. This seems to me to be very strong evidence in favor of the view that the Egyptians knew of the nineteen years' cycle, and that the Jews brought the knowledge away with them.

Those learned in Assyrian antiquities tell us that the book containing "The Observations of Bel," the oldest astronomical book of that part of the world, was ordered to be kept by the king 3,800 years before Christ; that book shows that they kept a record of astronomical and all other events, that they had discovered the nineteen years' cycle of eclipses, and we are told that it was a doctrine with them, that one event caused another, and all astronomical and meteorological observations were thus bound up together. Under such conditions I do not think it would be possible for them to avoid finding in the droughts a similar period to that in the eclipses, i. e., nineteen years; but even if they did, it would have been impossible for those who kept the Nilometer in Egypt to avoid finding it in the heights of the Nile floods, which were of such vital importance and so carefully recorded.

Since I have been working at this subject there have been a number of red rain storms noted in New South Wales, and the latest, on April 10, suggested to me this line of investigation. Red dust is obviously a proof of drought somewhere, otherwise the dust could not rise; and since these proofs of drought are entirely apart from the others, and recorded not as droughts but as marvels, which in days gone by created no little alarm, it will be worth while to see how far they support or contradict the nineteen years' cycle. The result of this resolution came as a surprise to me, because it was so unexpected; I had no idea there were so many records of red rains, or that they went so far back in history.

There are altogether sixty-nine recorded instances of the fall of red rain; of these I have recorded six for New South Wales. The first was fourteen years after the foundation of the city of Rome, that is in B. C. 738, and there are nine others before Christ, all of which fit into the nineteen years' cycle; between B. C. 538 to A. D. 582 I can find no record of red rain, but from 582 to 1896 there are fifty-nine recorded falls of red rain, and all of them fit into the nineteen years' cycle. We have here, then, ten before Christ droughts which go with the eight mentioned before to make eighteen before Christ droughts in support of the cycle, the remainder, fifty-nine, are included in the previous list.

I have endeavored to put before you some of the reasons which have convinced me that there is a cycle in weather; but the necessity for brevity in order to keep within the limits of one address has rendered it necessary to express in a few sentences the results of many separate investigations, and the evidence does not seem so strong when thus condensed as it does when a number of facts one by one are brought to light from diverse sources, all of which individually support the proposition. I can assure you that the evidence was far more convincing when taken in detail; but want of time to get these details into one address make this course impossible. Enough appears to have been said to prove that the cycle does exist, and to show the very great importance of this rediscovery of a law of climate which, there are many reasons to think, was well known to the Jews, the Egyptians and other ancient peoples; they at least knew how to forecast droughts successfully, and in Egypt, like sensible people, made provisions for them.

An examination of the weather of one hundred years of New South Wales has shown that certain features recur every nineteen years; we have seen that the droughts of history—the great and conspicuous droughts I mean—all drop into this same cycle; both those that happened before the birth of Christ and those that have occurred in our era; for instance, Elijah's drought happened in B. C. 908, that is, 2736 before our great drought in 1828, and the interval is 19×144. Great hurricanes, the great frosts of history, all the red rains, and all the droughts that history records, with a very few exceptions, likewise are included in this cycle, and the level of great lakes in Palestine, South America and New South Wales are subject to the same mysterious influence that controls our weather.

As my investigation proceeded, the weight of evidence gradually converged upon the moon as the exciting cause. I have never had any sympathy with the theory of lunar influence upon weather, and received, rather against my will, the evidence that presented itself. Still the logic of facts left no alternative but to accept the moon as prime motor. There has not been time to complete this investigation, and when finished it must form another paper. Meantime I may say that, so far, the comparison of the moon's positions in relation to the sun and earth and droughts shows that when the eclipses congregate about the equinoxes, that is, in March and September, they do so in the years which give us great droughts. Further, that when the eclipses accumulate in February and March, that is, at the vernal equinox and the month before it, and September, the autumnal equinox, and the month before it, August, we have the more intense and relatively shorter droughts of the second series; with heat, gales and hurricanes: on the other hand, when they accumulate about March and April, that is, the month of equinox, and the one following, and about September, the month of equinox, and October following it, we have droughts of the first series that are less severe, but much longer than the droughts of the second series. I have spoken chiefly of droughts; though, so far as our own history is concerned, it would have served the purpose just as well if I had taken up the periodicity of wet years, but outside Australia it would have been very difficult to get the necessary data, for history has much more to say about the horrors of drought than the abundance of wet seasons.

FERULA FŒTIDA.

The identification of the plant producing the drug known as asafœtida is a matter upon which some doubt is still experienced. Indeed, it is not at all unlikely that more than one species yields this disgusting, but sometimes serviceable, medicament. Our present illustration is taken from a photograph sent by Mr. Buysman, of Middleburg, Holland, the well known collector and preparer of botanical specimens. Ferula asafœtida was originally described by Linnæus, but the best recent account is that of Boissier, Flora Orientalis, ii, 994, if, indeed, his plant be the same as that of Linnæus. Our illustration gives a sufficient idea of the habit and general appearance of Mr. Buysman's plant. It is a native of Persia, Afghanistan, and southern Turkestan.

FERULA FŒTIDA.

Dr. Aitchison, in the "Botany of the Afghan Delimitation Commission" (Trans. Linn. Soc., April, 1888, p. 69, tt. xii to xiv), refers to Boissier's plant under the head of Ferula fœtida of Regal (1877), which is apparently not considered the same as Linnæus' plant (see also Aitchison, in Pharmaceut. Journ. and Trans., 1887, p. 465). If Mr. Buysman's plant be identical with that of Regal and Aitchison, it should bear the name F. fœtida, but this is a point upon which we can express no opinion, not having compared the specimens. We may, however, append Dr. Aitchison's remarks:

Ferula fœtida. — "Native names; Anguza-Kema, Kurne-Kema, Khora-Kema; stems from 3 to 5 feet in height, from a perennial root stock that produces annual radical leaves for several years, and then a flowering stem, and upon the fruit ripening the plant dies. The young flowering stem, rising from a tuft of radical leaves, appears in the form of a cabbage, being at first wholly inclosed in the broad stipular expansions, or bracts, to which the cauline leaves are reduced; and when the growing branches of the inflorescence first push them open, the whole plant resembles a cauliflow-

or. The stem seems out of all proportion, massive, pillar-like, and stout for the plant. The inflorescence is globose, and from 1 to 2 feet in circumference. The flowers are white, and the young fruit soon takes a more or less purplish tinge. In all stages of its growth every part of the plant exudes, upon abrasion, a milky juice, which is collected, and constitutes the drug of commerce called asafœtida. The stem in a young state is eaten raw or cooked."—The Gardeners' Chronicle.

A TIDAL WAVE IN JAPAN.

THE catastrophe that occurred on the sixteenth of June in the northern provinces of Iwate, Miagi and Aomari is one of the most terrible on record.

The victims reached the number of thirty-five thousand, and the three huge ground swells that succeeded one another within the space of about ten minutes devastated the region and swallowed up habitations, men and animals for an extent of one hundred and sixty miles of the coast.

It is supposed that an upheaval must have taken place in the bed of the Pacific Ocean or that the disaster was occasioned by an earthquake. The first conjecture would seem to be the most probable, since, after the water receded, there were discovered the remains of certain mollusks that are capable of existing only at a depth of from five to six hundred feet.

Some of the witnesses of the phenomenon say that in the wake of terrible subterranean rumblings they saw the billow advancing like a huge and solid wall of liquid twenty feet in height. The few persons who were spared were dumbfounded and scarcely thought of their safety. They wandered aimlessly and confusedly upon the immense devastated strand, and were unable to believe in the reality of so unheard of a disaster.

As soon as the news reached France our government addressed its condolences to the Mikado.

In a publication entitled "The World as Seen by the Scientists of the Twentieth Century," Mr. Bouquet de la Grye gives a thrilling recital of facts of the same kind, of which the world preserves a sad recollection.

He recalls that the old city of Callao was destroyed in 1746 by an irruption of the sea due to an earthquake. A wave sixty feet in height swallowed up everything, after stranding all the ships in the roadstead. A frigate was stranded upon the church square in the middle of the city.

In Japan, in December, 1854, a wave thirty feet in height, followed by five smaller ones, razed the city of Samoda. This tidal wave was registered on the other side of the Pacific by abnormal movements of the sea at San Francisco, Astoria and San Diego.

In 1820 a quaking of the earth led to an analogous disaster at Acapulco. The ground rose, in the first place, thirty feet, leaving the roadstead high and dry, and then it subsided forty-five feet, when the sea abruptly advanced and literally swept away the city. In this case, it was a terrestrial phenomenon that preceded the catastrophe.

On the 26th of August, 1883, in the wake of a formidable eruption of the celebrated volcano of Krakatoa, Java, Sumatra, Ceylon and a portion of the Indies were shaken by formidable detonations. The port and city of Telogbetoeng, in the bay of Lampong, were carried away by a huge wave. The singular tints of the sky at sunset (probably due to dust and vapor in suspension in the atmosphere) that were for a long time seen in Europe are still remembered.

Tidal waves therefore appear to be due in most cases to seismic phenomena which are themselves connected with volcanic eruptions. The sudden penetration of volumes of water into the depths of the earth would produce intense disengagements of gases capable of uplifting mountains of water that would afterward fall upon the shores. Japan, which is subject to frequent earthquakes, seems, unfortunately for it, to be particularly predisposed to such natural cataclysms. Nevertheless, tidal waves are, with less violence, known in Holland, Denmark and the North Sea. The great gulf of Zuyder Zee seems to be the sinister result of a tidal wave, and the coasts of the English Channel are not exempt from such phenomena. Up to the present, no law of periodicity has been observed for these phenomena.

It is considered safe to assert that the tidal wave of which it is a question in this article was the greatest one that has been observed since that to which the explosion of Krakatoa gave rise. That wave made the tour of the world, and the effect of it was felt by the mareometer of Havre.—Le Monde Illustré.

JAPAN'S CHEAPEST LABOR.

ROBERT P. PORTER writes from Osaka, Japan, to the New York Sun as follows:

Osaka is bewildering. Its antiquity fascinates, and its modern possibilities give rise to endless speculation. Its rapid growth of late years as a center of manufacturing activity excites astonishment. Its location, taken in conjunction with the important port of Kobé, within a radius of twenty miles, is superb, both for commerce and manufacture. The head, as it were, of the beautiful inland seas, it has a direct and easy outlet, not only to all the Japanese ports and inland possessions as far south as Formosa, but it is also within a few days' passage of Corea, Vladivostock, the Russian port, and the principal commercial cities of China With China open for trade and manufacture, Corea building railroads and developing its resources, the civilization of rich Formosa, and the prospect of Russia completing the great transcontinental Siberian railroad, with a terminus on the Sea of Japan, the whole Asiatic world, with its hundreds of millions of population, lies within easy access of the mighty producing district now building up on the Bay of Osaka.

Already is massed around this bay and the adjoining district of Kioto an industrial population of about 3,750,000. Nor does this represent the reserved strength of Osaka. Within a radius of a hundred miles we have a population of nearly 16,000,000. Across the bay, a distance of sixty miles, is the island of Shikokiu, with an additional 3,000,000. In this circle may be found nearly all the great cities of Japan, except Tokio and Yokohama. There are Kioto, the ancient capital, with a population of 350,000; the well built, clean, and modern city of Kobe, by far the most important port of Japan, with 175,000 population; Nagoya, now a thriving manufacturing place of 225,000 people; Sakai, the seat of the rug and metal industry, with a population of over 50,000; Fukui, the center of a district producing over half the silk habutai manufactured, and sixteen other places, all over 30,000 population, and all bound to form, as the railroad system extends, important connections with the population around the Bay of Osaka. Here we have, within two or three hours of Osaka by rail, an industrious, skillful, thrifty population, full of ingenuity and enterprise, and fully imbued with the

A TIDAL WAVE IN JAPAN.

spirit of progress and impressed with the future industrial supremacy of Japan, at least in the Pacific and Asia.

In appearance Osaka presents some striking contrasts. From the windows of the railway cars it might be a Cleveland or even a Chicago, for its innumerable tall and iron chimneys, which belch forth the blackest kind of smoke. The factories and mills are of red brick and built after the plan of our own, except that, on account of earthquakes, they are not over one and two stories in height. The immediately surrounding country is flat for many miles, affording ample room for a city of five millions, before the picturesque hills and mountains, which loom up a shadowy background to this scene of human endeavor, are reached. While its mighty factories and mills, some employing two and three thousand hands, suggest our own cities, the several branches of the river and innumerable canals bring to mind Amsterdam and Venice. Osaka is not only surrounded by water, but canals, some of great width, run through the busiest districts. From the bay and river eastward there are at least ten canals all running into the central canal, which extends north and south through the heart of the city and forms the boundary between the west and east ends. The east district is again divided by a canal, fed from the branch of the river, running through the northern district of Osaka and connected by two branches with the other north and south branches. This network of canals, laden with barges and boats of every sort and kind, relieves the streets of the tremendous pressure of transporting the fabrics of the mills, shops and factories and the provisions for the millions of people depending upon the Osaka district for supplies. It is the city of boats and bridges. On the map before me I have actually counted 178 bridges, not little wooden structures, but well built substantial bridges of iron and stone and timber. Projecting over these canals are the thousands of dwellings where the population live and perform their domestic duties. High up above these houses, on scaffoldings, flutters yards upon yards of cotton cloth, blue and white and Turkish red, which had been dipped in the canals after dyeing, and are now undergoing the various drying and bleaching processes. This gives the scene almost a Turkish flavor.

The streets of Osaka are the busiest I have ever seen. They are literally thronged with human beings engaged in unceasing toil. The stores and shops are also workshops and warehouses. Clerks, designers, artisans, packers, carters, sellers, and buyers are so mixed up that the wonder is how they all unravel themselves and bring order out of the chaos which seems to reign supreme. In this respect you are reminded of the descriptions of those wonderful cities of the ancient world, where every man had a handicraft of his own, before the days of capitalization and centralization of industrial energy. The street scenes of Osaka are simply indescribable. Months could be profitably spent in walks and talks with those who thus ply their trades amid the never ceasing interruption of daily traffic. Now you pass through long streets given over to pottery and porcelain, next through one devoted to umbrellas, then one where matting is made, and this is followed by a vast emporium of cotton fabrics, of rugs, of brushes, of leather goods, of bronze and metal work, of provisions, of clothing.

Methods and implements take ranges or leaps, perhaps I should say, of a thousand years. Here are five men, with their bronze skins bare, save a breech cloth around the loins, pounding rice with a long wooden pole. Next door are a dozen operatives making garments with the latest American sewing machines. Over the Rice Exchange they are waving the quotations from hill to hill and peak to peak by means of flags. Within a stone's throw, at the magnificent post office building, may be heard the click of the telegraph instrument and the hello of the telephone. You may view within a few minutes the oldest and most primitive spinning wheel and the latest Fall River spindle, the clumsiest wooden loom and the most intricate Jacquard machine. A delirium of work pervades the people. In their eagerness to take part in the conflict, this industrial army has simply caught up every implement at hand, and with an expertness that is marvelous, is producing an infinite variety of excellent articles. Poorly equipped it is, but nevertheless it is marching onward.

The industrial soldiers of Japan are not waiting for the last man to be fully equipped with the latest modern device, but are forging to the front with just what they have, and only discarding the old implements when the better are at hand ready for operation. Herein lies their tremendous force. They are artisans by nature and by generations of experience. They know their trades thoroughly, and have no thought beyond the persistent endeavor to make the best of the situation, and to make Japan felt in the world's industry and commerce. Those who have sometimes gazed at the Pyramids and wondered how they were built without modern appliances should walk the streets of Osaka and see the mighty obstacles met and overcome by hand labor, pure and simple. The wants of forty-five millions of people, together with a foreign trade which will reach $300,000,000 this year, are all practically supplied by hand labor. A few ancient-looking bulls, with great rings in their noses, are the only beasts of burden I have seen here, save man. All else is moved by human muscle—except, of course, the machinery of the modern mills, where may be found the latest steam power.

When, however, this human labor, accustomed to an endurance that would appal an American or European laborer, is harnessed to modern machinery, it makes a combination which, with sufficient scope, must change the current of the world's industry. Take, for example, the industry of manufacturing matches. In a few years, with modern appliances, Osaka has been able to capture the entire Asiatic market for this staple commodity, and now it is pressing forward to Europe. This morning I visited one of the largest match factories in the outskirts of Osaka, employing 2,500 hands. Here the sticks are cut by machinery, they are sifted into little boxes by women, they are collected and put in frames by tiny waifs of children, some of whom do not look over three or four years old, and the majority of whom are under ten. The sulphur and paraffine are put on by hand presses, and then the matches dried in the sun. The boxes are made and labels put on by little girls, whose fingers are so nimble that the human eye is incapable of following the movements as the purple and yellow boxes drop (more than one a second) into the mighty baskets at their side.

Over twelve hours a day these little creatures labor for wages which range from one cent to five cents of our money a day. And they labor cheerfully. They sing and chatter and laugh and eat their tiffin, consisting of rice and fish, from tiny boxes with chop sticks, which they handle with as much dexterity as they do the matches. Here they sit the twelve long hours on the floor, in small pens about four feet square marked off by bamboo poles. Some of the rooms or sheds of these match factories suggest primary schools—they are so literally crowded with children, some laughing, some crying, some singing, some eating, but all toiling to earn their daily bread. There are no factory laws, no regulations as to the age at which children shall begin to work, no limitation of hours of labor at present in Japan. The government, however, and the sanitary authorities have taken the matter up, and in a few years a more humane system will be evolved. For the moment there is a scramble to utilize every pair of bright eyes and dexterous hands, regardless of future consequences.

The question which naturally occurs to one used to other conditions and environments is, How do these people manage to live on the wages paid? The average earnings for adults in these localities are certainly not over ten sen, or say five or six cents of our money a day. The children bring in addition say from one to two cents a day for twelve hours' dexterous work, making boxes, filling them with matches, labeling, and other light work. After my visit to the match factory, which was made accompanied by an English and an American gentleman, I took an able translator, son of a high official of Japan, and made an exploration of this entire district, including the famous Nagoya-machi of Osaka, a street often mentioned in Japanese drama, which answers to the Whitechapel Road, London, the Bowery, New York, or Scotland Road, Liverpool. Living in Osaka is cheaper than in any other city of Japan, so the result of the present personal inquiry may be taken as the lowest cost of living in the world. I have spent several weeks making similar investigations in Tokyo, but the scale is lower here than there, as food and lodging are both cheaper.

First, as to food. The greater number of shops on Nagoya-machi offer some kind of food. The most numerous are those which the denizens of this locality call vegetable shops, where cut-off ends of vegetables are offered for sale. Next come fishmongers' stalls, selling refuse of dried sardines, heads or skeletons of fish, entrails of fowls, and so forth. The price for these edibles is half a sen or five mats, about a quarter of a cent. The rin or tenth of a sen, a copper coin with a hole in the center, is in vogue in these localities. The houses, of course, are of wood, and contain nothing save a few crude cooking utensils and the mats upon which the occupants sleep. The rooms contain from two to four, and sometimes six mats, each about three by six feet. The rent, I found, ranges from two and one-half sen (one and one-fourth cents) a day for the best to one and two-tenths sen, or less than a cent American money, for the lowest. The average number of people sleeping in these tiny rooms or houses is about four. The death rate in these quarters is sometimes frightful, especially in the summer, when statistics show that it reaches in this district 492, against 231 births. The loss, as in our own cities, is constantly filled by fresh emigration from the country. Over ten per cent. of the population of the Nagoya-machi are matchmakers. The hours of labor and earnings of some of the peculiar professions of this quarter may be summarized as follows:

Occupation.	Hours of Labor.		Production.	Earnings.	
				Sen.	U. S. Money.
Sandal bottom fitting	6 A. M. to 6 P. M.	12	20 pairs.	8.	$0.04
Jinrikisha men	6 A. M. to 10 P. M.	16		18.	.09
Match stick packing	6 A. M. to 6 P. M.	12	1,240 boxes.	8.	.04
Match box making	6 A. M. to 6 P. M.	12	750 boxes.	3.5	.0175
Wagon pullers	6 A. M. to 6 P. M.	12		18	.09
Polishing sand selling	6 A. M. to 6 P. M.	10		2.5	.025
Shampooers	6 A. M. to 1 P. M.	7	5 rounds.	5.0	.025
Scavengers	6 A. M. to 6 P. M.	12		4.5	.0225
Begging	9 A. M. to 5 P. M.	8	300 houses	3.0	.015
Tobacco pipe menders	7 A. M. to 6 P. M.	11	6 pipes.	4.0	.02
Street singers, etc	7 A. M. to 5 P. M.	8	300 houses.	5.0	.025
Average		11		7.1	.036

In the above figures the calculations are not exact, but on the basis of one sen equaling half an American cent. In purchasing power here the Japanese sen is fully equal to our cent, and the fact that it takes ten rin (also a current coin) to make one sen indicates that purchases can be made for even that small coin, about 2,000 of which can be purchased for an American dollar. Throwing out jinrikisha men and cart drawers, it will be found that the average earnings above given are less than five sen, or two and one-half cents a day. Here is the daily outlay of a man earning say three American cents a day:

	Sen.
1 go of poorest quality rice	.8
Drinking water, one pail	.2
Subsidiary food	.3
Fuel	.3
Daily rent	1.5
Fund to the Jizo festival	.2
Total	5.3

A go is about one-fifth of a peck.

Thus we have the rock bottom facts. All over this amount, and, of course, the average well-to-do laborer here will earn from twenty to twenty-five sen (or 10 to 12½ cents) a day, enables him to improve the character and quantity of his food and to supply such luxuries as a mosquito net and a bed quilt.

Where living is so cheap, what does it cost to die? Statisticians, they say, follow us from the cradle to the grave, and hence I have learned something as to the cost of a funeral on the Nagoya-machi. When a family in these quarters of Osaka is stricken with such misfortune, it is a double blow, because the burial of the dead in accordance with the legal process, and in obedience of immemorial custom, involves the enormous expenditure of more than a yen and a half (about 78 cents, our money). Here it is:

	Sen.	U. S. Money.
Cost of coffin	40.	$0.20
Cost of cremation	75.	.75
Refreshments to sympathizers	21.	.105
Offering of flowers	.5	.0025
Doctor's certificate	10.	.05
Fee to priest	3.	.015
Fee to coffin bearers	14.	.07
Another religious service	3.	.015
	166.5	$0.8325

Less than a dollar to bury a man in good form. This cost can be somewhat reduced by a certificate to the authorities asserting the poverty of the family, but this is rarely done. Those better off generally assist, and even the poor neighbors of the locality in the event of death send in mourning presents of a few sens each, and in this way the disgrace of a pauper funeral is averted. What would the esteemed British laborer who looks forward with equanimity to ending his days in the "'ouse" and a pauper's grave think of these independent Japanese, who may eat mighty close at times but are too independent to accept calmly the life of a pauper, even though it means a comfortable bed and plum pudding and roast beef at Christmas?

One thing that strikes outsiders with curiosity about the dwellers in these quarters of Tokio is their religious predisposition. A small, half-decayed tabernacle, where a stone image of the Buddha is enshrined, is found in each nook and corner of this street. The dwellers are under obligation to contribute one-tenth to two-tenths of a sen a day to the religious ceremony fund, and on the two days of the 23d and 24th of July in every year a religious festival is held, when the street presents the most gallant spectacle which the fund admits, and when the hardship of the year is unbent. In the joys and rollicking of those days may the toilers of the Nagoya-machi forget their sorrows for a few hours, and in the happy-go-lucky disposition of these truly wonderful people relax themselves by such pleasures as these fetes afford.

LIFE IN THE MOON.

By Prince KROPOTKIN, in the Nineteenth Century.

THE beautiful big telescopes which are now at work at several observatories have rendered a new service to astronomy. They have given a fresh impulse to lunar studies, and once again the old questions as to the existence of air and water and the possibility of organic life on the surface of our satellite are discussed—this time with some prospects of a definite solution.

For some time past lunar studies have been decidedly falling into neglect. The immense, apparently lifeless plains of the moon, which still retain the name of "seas," or "maria," although no traces of present or past marine action can be detected on their surfaces; its immense circus shaped craters, which have no rivals in size on our own planet; its high chains of mountains and deep rents—all these had been minutely measured and mapped down to the smallest craterlets, with the hope of discovering some signs of life, or of change going on on the moon's surface; and yet no such signs were forthcoming, at least in a definite form. There was, of course, a small group of devoted selenographers, Neison in this country, Klein in Germany, Oscar Schmidt at Athens, who continued to give their lives to a minute study of the visible surface of the moon. With instruments of a modest power they achieved real wonders in delineating the minor details of lunar topography, and from time to time they caught glimpses of such appearances as seemed to indicate the presence of water in certain cavities, or a periodical growth of some vegetation, or, at least, a still continuing volcanic activity. But each time such appearances were studied in detail, it became evident that unless more powerful instruments were directed toward our satellite, there was little hope of solving those questions relative to life which, in astronomy as everywhere else, chiefly fascinate man. Gradually it began to be said that we already know about the moon all that can be known, and interest in lunar studies waned among astronomers.

And yet, in reality, our knowledge of the moon is still very limited. Our best map of its visible surface, although it is a marvel of accuracy, represents it only on a scale of 1 to 1,780,000, which is quite insufficient to show even such changes as are still going on on our own globe.* We know, indeed, that in our lifetime

* The moon has on this map a diameter of 75 inches, while its real diameter is 2,160 miles.

many changes have taken place in the shapes of our hills, valleys, river courses, and ocean shores; but what could we know of such changes if we only had small maps to compare? Moreover, only now, with such big instruments as the Lick telescope, which has a glass lens [36 in. in diameter, or the admirable Paris telescope (24 in. lens), we can distinguish, under the most favorable circumstances, the valleys and the hillocks, which are from 650 to 1,000 ft. in width; but until quite lately, all we could see were objects over one or two miles wide; so that it has been truly said that if all the knowledge of the earth by a man in the moon were of the same sort, he also might represent our planet as an arid, dreary body with no traces of life upon it.*

Photography undoubtedly supplied astronomers with a precious aid. Already in the admirable photograph of the moon which was made in 1865 by Rutherford, and still more in modern photographs, the circuses, the plains, and the mountains appeared with a relief and reality of which the best maps gave not the faintest idea. But lunar photography is beset with so many difficulties, chiefly on account of the irregular proper movements of the moon, that up till now the largest photographs obtained were less than 8 in. in diameter. And it was only quite lately that they could be enlarged ten, twenty, and even thirty-three times, without the details being blurred. Some of the negatives obtained at the Lick Observatory and at Paris by the brothers Henry, in an especially quiet and favorable atmosphere, were even so clear, that it was found advisable to carefully examine them under the microscope, and to make with the hand detailed enlarged drawings from the best of them.†

An examination of such enlarged photographs, which permits us to embrace with the eye a large surface, filled with a mass of nature true details, has led MM. Loewy and Puiseux ‡ to some interesting suggestions concerning the origin of the so-called "rills" or groups of parallel rents in the moon's crust.§ And on the other side of the Atlantic, the direct observations lately made by Prof. W. Pickering, under the clear sky of Peru, as well as his studies of the American photographs, have produced such new data concerning the atmosphere of the moon, and the possible existence of water on its surface, as are sure to give a quite fresh interest to lunar studies.‖

The moon is so small in comparison with the earth (its weight is eighty-one times less), and consequently the force of gravity is so much smaller on its surface, that, even if it had an atmosphere of the same composition as ours, its density in its lowest parts would be from thirty to fifty times less than the density of our atmosphere at the sea level. But it appears from Dr. Johnstone Stoney's ¶ investigations, that even if the moon was surrounded at some time of its existence with a gaseous envelope consisting of oxygen, nitrogen, and water vapor, it would not have retained much of it. The gases, as is known, consist of molecules, rushing in all directions at immense speeds; and the moment that the speed of a molecule which moves near the outward boundary of the atmosphere exceeds a certain limit (which would be about 10,600 feet in a second for the moon) it can escape from the sphere of attraction of the planet. Molecule by molecule the gas must wander off into the inter-planetary space; and, the smaller the mass of the molecule of a given gas, the feebler the planet's attraction, and the higher the temperature at the boundary of its atmosphere, the sooner the escape of the gas must take place. This is why no free hydrogen could be retained in the earth's atmosphere, and why the moon could retain no air or water vapor.

However, neither these speculations, which are very likely to be true, nor Bessel's previous calculations, could convince practical astronomers of the absolute absence of any atmosphere round the moon. A feeble twilight is seen on our satellite, and twilight is due, as is known, to the reflection of light within the gaseous envelope; besides, it has been remarked long since at Greenwich that the stars which are covered by the moon during its movements in its orbit remain visible for a couple of seconds longer than they ought to be visible if their rays were not slightly broken as they pass near to the moon's surface. Consequently, it was concluded that the moon must have some atmosphere, perhaps only two hundred times thinner than our own. Of course, a gaseous envelope so thin as that would only be noticeable in the deeper valleys, and it would attain its greatest density within the circus-like cavities whose floor, as a rule, lies deeper than the surrounding country. Toward the tops of the mountains it would be imperceptible. But, nevertheless, as was shown by Neison, it would play an important part in the economy of life on the moon's surface.

The observations made at Lick, at Paris, and at Arequipa fully confirm this view. A twilight is decidedly visible at the cusps of the crescent moon, especially near the first and the last quarter. It prolongs the cusps as a faint glow over the dark shadowed part for a distance of about seventy miles (60"), and this indicates the existence of an atmosphere having on the surface of the moon the same density as our atmosphere has at a height of about forty miles. A similar result is obtained when the slight flattening of the disk of Jupiter, which takes place when the planet is just going to be covered by the moon or emerges from behind it, is measured on the Arequipa photographs. Such an atmosphere is next to nothing, but there is another observation, namely, of a dark band appearing between Jupiter and the moon's limb when the former begins to be covered by the latter; and Prof. Pickering finds no other explanation for it than in some very light haze, partly due to water vapor, which would rise a few miles above the moon's surface where it is illuminated by the rays of the sun.

Such a supposition would have been met some time ago with great suspicion. But it must be said that the more the moon's surface is studied in detail, the more astronomers are inclined to think that, in some places at least, a haze, originated from water vapor, is the only possible means to explain certain curious occurrences. Thus, Dr. Sarling has lately reminded us that, in 1774, Eysenhard, a pupil of Lambert, saw the part of the shadow line which crossed one of the plains (the Mare Crisium) brought in a wavelike movement which lasted for two hours and was seen by three different persons—only in this part of the lunar disk. Those undulations, which spread at a speed of one thousand two hundred feet per second over a distance of eighty miles, could only be due—as Dr. Sarling truly remarks—to vapors floating over the plain.* In several instances the interiors of deep lunar circuses took a misty appearance at sunrise, and this misty appearance disappeared as the sun rose higher above the same circus, while in other cases it persisted a considerable time after sunrise, even though all around was sharply marked and distinct.† And so on. The temperature of the moon's surface, when it is heated by the sun's rays, being very near to the freezing point, as appears from Langley's last measurements, the evaporation of frozen water under the rays of the rising sun is surely not at all improbable.

It remains, of course, to be seen whether a haze of this sort is not due in some cases to water ejected by volcanoes or geysers; the more so as some volcanic activity, remodeling until now the forms of the craters, seems to exist. There is, indeed, among astronomers a strong suspicion of a lunar crater nearly three miles in diameter, being of recent formation. It was first discovered by Dr. Klein in 1876 in the plain named Mare Vaporum, after he himself and many others had previously so often examined that region without seeing the crater. Besides, the alternate appearance and disappearance of another crater (Linné) nearly four miles in diameter can hardly be explained unless it be concealed from time to time by the vapors which it itself exhales. As to changes observed in the shapes of small lunar volcanoes, they are too numerous to be due to mere errors of observation.‡

If free water thus exists occasionally, even now, on the moon's surface, or has existed at a relatively recent period, it is natural to ask whether it has left no traces of its activity. Are there no river valleys which would bear testimony to its existence? Till lately the majority of astronomers answered this question in the negative, even though their earlier predecessors, armed with feebler telescopes, were most affirmative on this point. The maria or seas are known to be plains on which no traces of aqueous action have been detected, and the clefts or large "rills" are almost certainly rents produced in a solid surface.

However, beside these clefts, there are much finer formations which only lately have received due attention, and these finer rills have all the aspects of river beds. They are not straight lined, but wind exactly as rivers wind on our maps; they fork like rivers; they are wider at one end than at the other, and one end is nearly always higher than the other. Many such fine rills have been observed and mapped lately, and Prof. W. Pickering gives a list of thirty-five presumable river beds—large, medium sized and very fine.§ However, contrary to most terrestrial rivers, the lunar river beds —those, at least, which were observed by W. Pickering —have their wider end in their upper course, nearly always in a pear-shaped craterlet. This circumstance offers, however, nothing extraordinary, as we know many rivers in Central Asia and South America which originate in a lake and grow thinner and thinner as they enter the arid plains.

To take one illustration out of several, one such river, sixty-five miles in length, with all its windings, rises in a craterlet, perhaps two thousand feet wide, but soon its valley narrows to one thousand feet or less and is lost in a plain. Occasionally such rivers occur in groups on the slopes of the mountains. Other river beds, on the contrary, seem to have the normal characters of our rivers. One of them begins in the mountains as an extremely fine line, gradually increases in width, and, after having received a tributary, becomes a broad but shallow valley. Another bifurcates into two very fine lines in its higher part.‖ In short, it may now be taken as certain that there are river beds to all appearance of aqueous origin; but they are so narrow that we should not be able to discover watercourses if they existed at the bottom of these valleys. We must be content with saying that they have been scooped out by running water.

So much having been won, the next step was naturally to ask if no traces of vegetation can be detected. On Mars we see how every year a snow cover spreads over the circumpolar region, how later on in the season wide channels appear in it, and how the snow thaws gradually, presumably giving origin to water; even clouds have lately been seen; and we can notice, moreover, how the coloration of wide surfaces changes, probably because they are covered with vegetation, and how that coloration gradually takes a reddish yellow tint.

Of course, if anything of the sort took place on our nearest neighbor, the moon, it would have been noticed long since. But it would be most unwise to maintain that nothing similar to it happens on a much smaller scale. On the contrary, Prof. Pickering shows that there are some probabilities in favor of plants of some sort or another periodically growing on the moon as well.

The great lunar circuses or craters attain, as is known, colossal dimensions; the largest of them have one hundred and one hundred and thirty miles in diameter, and the floor of their inner parts is mostly flat. Now, Neison has already made the remark that gray, almost black, spots appear on the floor of certain craters at full moon, but disappear later on, and W. Pickering has carefully investigated several such spots during his unfortunately too short stay at Arequipa. Contrary to all expectations, they grow darker just after full moon, that is, when the sun strikes the visible part of the moon's surface in full and when it is geometrically impossible for any shadow to be visible, and they become invisible when the sun is lowest and the shadows are evidently strongest.

We know, however, of no stone which would darken under the action of sunlight and grow lighter when the sunlight fades, and, following two such authorities as Mädler and Neison, Prof. Pickering inclines to see the causes of those changes in vegetation. Such spots, whose darkness varies with the sun's altitude, are not mere accidents. On the contrary, they have been found on all plains, with the exception of one, and in two plains, the Mare Tranquillitatis and Mare Nectaris, they apparently cover the whole floor, their changes being sometimes so conspicuous as to be almost visible to the naked eye. In the craters they always appear in the lower inner edges, but never on the tops of the walls, and rarely, if ever, on the outer walls. As a rule, they are colored in dark gray, but in one case, at least, one of the spots, examined with a great power, was of a "pronounced yellow color, with perhaps a suspicion of green."

These observations,* which Prof. Pickering unhappily found impossible to continue under the much less propitious sky of Massachusetts, "on account of the poor quality of the seeing," are certainly very promising, the more so as they are not isolated. For the last few years a number of data are accumulating, all tending to prove that it was too rash to describe the moon's surface as utterly devoid of life. It appears very probable, on the contrary, that volcanic changes continue to go on on the moon's surface on a larger scale than on the earth, and that, notwithstanding the most unfavorable conditions for organic life which prevail there, such life exists, be it only on a small scale. This is certainly very far from the sanguine affirmations of the last century selenographers, who wanted to see on the moon "fortifications," "national roads" and "traces of industrial activity." Such objects, if they did exist, could not be seen with our best instruments. But traces of vegetation which develops at certain periods and fades next, traces of water which runs, perhaps, even now, as well as indications of volcanic changes of the surface, become more and more probable in proportion as we learn to know our satellite better.

FLOATING OF METALS ON LIQUIDS.

PROF. A. M. MAYER, in an article on the "Surface Tension of Liquids," in Science, says:

In the present stage of the research I am inclined to hold the opinion that the flotation of metals and of glass depends on a film of air which is condensed on their surfaces. The following experiments seem to sustain this opinion. If a ring made of platinum wire $\frac{1}{10}$ millimeter thick, which really floats on water, is heated to redness and as soon as cold is placed on water, it sinks. Also, when withdrawn from the water and wiped dry, it again sinks when placed on the water; but after the same dried ring remains about a quarter of an hour exposed to the air, then it will float. If the platinum ring, after having been heated to redness, remains in the air about an half an hour and then is placed on the water, it floats.

Glass behaves in a similar manner to platinum. If a rod of glass, recently drawn out in a spirit flame and just cold, is placed on water, it sinks. After a freshly made rod has remained exposed to the air about a quarter of an hour, it will float. If a recently made glass rod which has just sunk in water be withdrawn, wiped dry and exposed to the air for a quarter of an hour, it will float. The glass rods used in these experiments are one millimeter thick and four to five centimeters long.

A valuable prize has recently been awarded by the French "Society for the Prevention of Accidents in Industrial Pursuits," for the best form of respirator produced, to Dr. Detourbe, whose design has now been adopted in quite a number of the most important workshops in northern France. The arrangement in question is described as a mask so shaped as to fit the lower half of the face closely, but not so as to interfere with the wearer's vision; a chamber in the middle, through which the air is filtered, which projects only a slight distance from the rest of the mask, contains a layer of asbestos and also one of cotton or wool, arranged between small plates of aluminum gauze. The mask is of copper, and a strip of elastic felt runs around the inner surface near the edge, thus insuring the necessary contact all around, and the device is held on with light elastic bands encircling the head, one being on a level with the forehead and the other about opposite the lower lip. The orifice is of such a size, and the lining of the chamber so loosely packed, that the wearer of the appliance is enabled not only to breathe, but to talk without difficulty, these two points constituting the great advantages of the invention.

* There is no lack of excellent works, most attractively written, in which all information about the moon may be obtained. Suffice it to name the following: Gwyn Elger's The Moon, London, 1895; Edward Neison's The Moon and the Condition and Configurations of its Surface, London, 1876; the English translation of Flammarion's Astronomie Populaire; and the excellent work of Miss Agnes Clerke, A Popular History of Astronomy during the Nineteenth Century, 3d edition, London, 1893.

† Great doubts were expressed at the outset as to the advantages offered by photography for the study of the moon. The advantage of the relief representation of the surface is, however, self-evident. Besides, with the aid of photography, a continuous record of the moon's aspect is kept, and every modification of detail which may occur in it will be settled for subsequent reference by unimpeachable testimony. It hardly need be said that in one favorable night many photographs are taken, and that such a mass of details is thus recorded that it would take one's lifetime to map them by hand. As to the enlarged drawings which were made by Dr. Weineck, who is well known for his skill in that sort of work, they have met with a good deal of criticism (from Dr Klein in Sirius, 1894 and 1895, and the Belgian Prof. W. Prins in Ciel et Terre, ii, 1895, p. 449), but it may now be taken as certain that they really contain a mass of details which may be seen directly even with smaller telescopes, but had been overlooked; while the appearance of the same detail on two or three negatives settles all possible doubts as to its reality. (L. Weineck and E. S. Holden, "Selenographical Studies" in Publications of the Lick Observatory, 1894, vol. iii; Loewy and Puiseux, in Comptes Rendus, tome cxix, p. 254, and tome cxxi, pp. 6, 79; Folie, Bulletin of the Belgian Academy, 1895, vol. xxix, No. 1; and Dr. Klein in Sirius, 1895, p. 112.)

‡ Comptes Rendus, 8 juillet, 1895, tome cxxi, p. 79.

§ To explain the origin of these rents, Loewy and Puiseux look for the time when the rocks were in an igneous half liquid state and floating islands of consolidated scoria were formed on the surface of the molten rocks and drifted like the ice floes in the Arctic Ocean. Remaining in that sphere of ideas, it may, however, be remarked that the same rents might have originated when the whole crust was already solidified. When Lake Baikal is covered with a thick sheet of ice, and the level of the water goes slightly down in the winter, the ice is intersected by long rents, one to ten yards wide, which usually appear in about the same places and in the same directions. They run in straight lines, have vertical sides, and when the water at their bottom is frozen, they become miniature models of lunar rents.

‖ William H. Pickering, "Investigations in Astronomical Photography," in Annals of the Astronomical Observatory of Harvard College, vol. xxxii, part I (Cambridge, Mass., 1895). See also Dr. Klein's analysis of the same (Sirius, 1895, Hefte, 7, 8 und 9).

¶ "On the Physical Constitution of the Sun and Stars," in Proceedings of the Royal Society for 1868; and paper "On the Cause of Absence of Hydrogen from the Earth's Atmosphere, and of Air and Water from the Moon," read on the 20th of April, 1892, before the Royal Dublin Society.

* Sirius, 1895, vi, p. 134.

† Edw. Neison, "The Moon and the Condition and Configurations of its Surface," p. 33 (London, 1876).

‡ The Observatory, June, 1892; Nature, vol. xlvi, p. 134.

§ Annals of the Astronomical Observatory of Harvard College, vol. xxxii, part I, p. 87.

‖ Dr. Sarling's letter to Sirius, March 30, 1895; map of the region near Herschel, f, made by J. N. Krieger at the Observatory of Trieste in same periodical, September, 1895, p. 195.

* In the above mentioned volume of Harvard Annals they are published in full, and are illustrated by a number of excellent photographs.

THE PELTON WATER WHEEL AT THE NORTH STAR POWER PLANT.

The paper read by Mr. Arthur de Wint Foote, C.E., at the meeting of the American Society of Civil Engineers, recently convened in San Francisco, elicited much interest and no small amount of discussion.

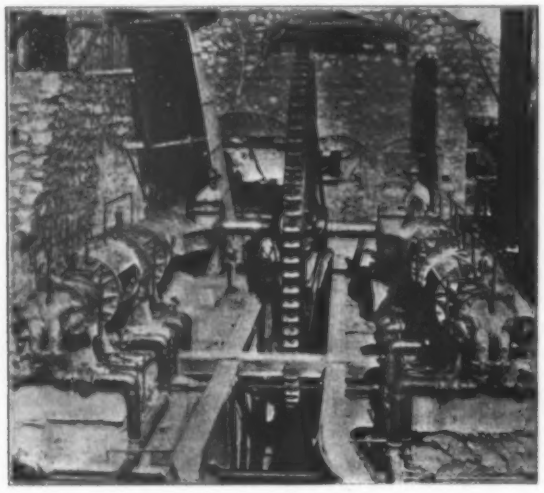
The paper referred to makes a very elaborate and exhaustive report upon the operation of the compressed air transmission plant at the North Star Mine, in Grass Valley, Cal., a brief description of which compiled from this report we here present.

The power station consists of a Pelton wheel 18 ft. 6 in. in diameter, attached to the shaft of a Rix duplex air compressor, compound tandem type. The initial tion absolutely automatic, as well as economizing the water supply, no more being used at any time than required for the work.

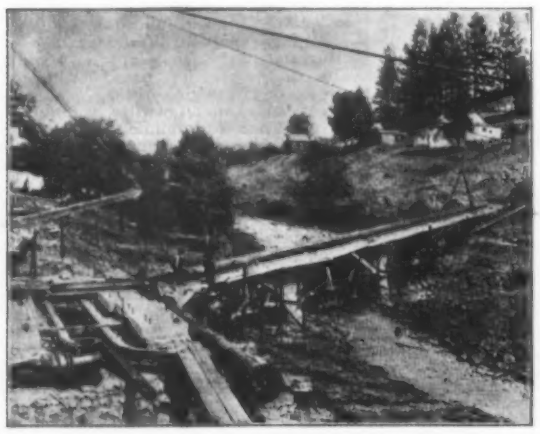
The wheel was made from designs furnished by Mr. Edward S. Cobb, of this city, and the construction, as will be seen, forms an ingenious mechanical combination, altogether novel and without precedent, affording an ample factor of safety, with a very high peripheral velocity. The water supply is brought to the wheel through 2½ miles of 22 in. riveted pipe, affording sufficient capacity to develop 800 horse power. A 3 in. lap weld pipe conveys the air at a pressure of 90 pounds from the power house to the company's shaft—800 ft. distant and 125 ft. elevation. This is at present running a 100 horse power pneumatic hoisting engine

THE FRENCH MOTOR CARRIAGE RACE.

The fears that were entertained in some quarters as to the probable failure of the race of mechanical vehicles from Paris to Marseilles and back have proved groundless. At one time there certainly was some justification for the pessimistic forebodings of people who looked with alarm upon the rapid dwindling away of the competitors in the earlier stages, and wondered whether a single vehicle would be left to retrieve the honor of the new system of road traction. Of the thirty-two carriages that started from Versailles only twenty-seven reached Auxerre, and on the following day this number was reduced to seventeen, so that it looked as if but a remnant of the vehicles would be able to

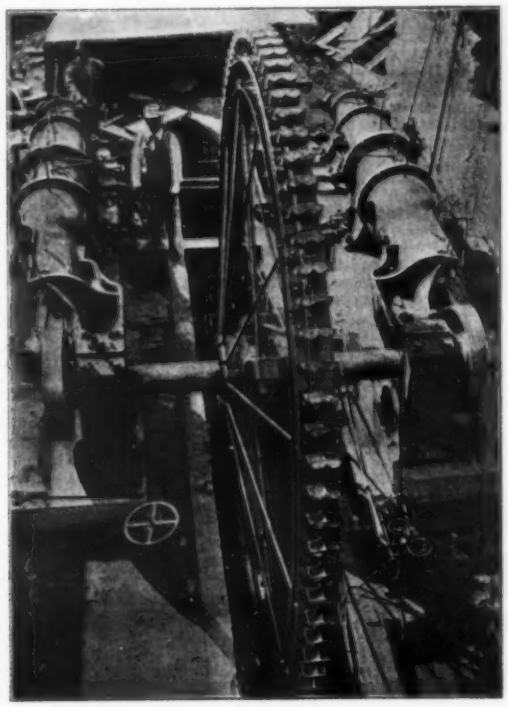


THE PELTON WHEEL AND COMPOUND TANDEM COMPRESSORS.

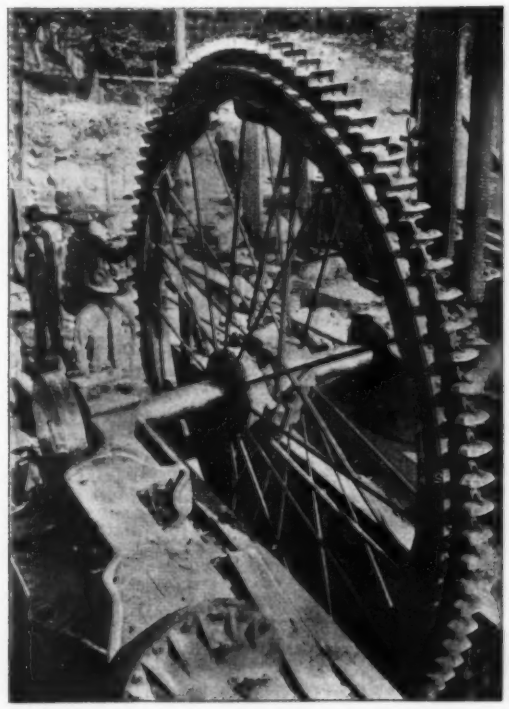


THE 22 INCH WATER PIPE ON TEMPORARY TRESTLE, AND THE FOUNDATIONS FOR COMPRESSOR, NORTH STAR POWER PLANT.

AQUEDUCT FOR THE 22 INCH WATER PIPE LINE, NORTH STAR POWER PLANT.



FRONT VIEW OF 18½ FOOT PELTON WATER WHEEL.



REAR VIEW OF 18½ FOOT PELTON WATER WHEEL.

cylinders are 18 in. and the second cylinder 10 in. diameter, with a 24 in. stroke.

The wheel is built up of angle iron plates riveted together to break joints, and is held concentric with the shaft with twelve pairs of radial spokes of 1¼ in. rod iron secured by nuts to the cast iron hub. The driving force being applied to the rim, is transferred to the hub by four pairs of 2 in. iron rods so arranged as to form a truss. The wheel weighs 10,500 pounds and runs at 110 revolutions under 750 ft. head, developing upward of 300 horse power. It is made of this large diameter for the purpose of giving proper speed to the compressor under the high head available. The water is applied to the wheel through a variable nozzle controlled by a hydraulic regulator which maintains a uniform speed on the wheel with a variation from full load down to 25 per cent. of the same, making its opera- and a 75 horse power compound pump, besides other pumps, drills, forges, etc.

The report above referred to shows that repeated tests on this wheel made by the most approved methods and checked up very closely give the remarkable efficiency of 93 per cent. at full load, also an average efficiency of something over 90 per cent. for ¼, ½, ¾ and full loads. The suggestion has been made that the extraordinary efficiency here shown is accounted for in part by its unusual dimensions. This, however, was shown to be incorrect, as equally high efficiencies have been obtained on Pelton wheels of much less than one-third this diameter. The efficiency of compression and transmission from water wheel to motors, not including cost of reheating, is given as 75 per cent., making a most favorable showing for the plant as a whole, under the conditions here installed.

reach Paris. Then they dropped off by twos, until on reaching Marseilles there were only thirteen competitors, but as others had resumed the journey after effecting repairs, it was quite likely that the number would be increased.

On the return run from Marseilles the conditions were much more favorable than in the first half of the journey, though for three days the competitors had to struggle along against a strong head wind, and this made fast running out of the question. With three vehicles that had arrived during the night or on the morning of September 29, the number of starters from Marseilles was brought up to sixteen, as follows:

No. 6, Panhard and Levassor; No. 44, Peugeot; No. 46, Peugeot; No. 15, Dion tricycle; No. 5, Panhard and Levassor; No. 8, Panhard and Levassor; No. 41, Delahaye; No. 29, Maison Parisienne; No. 26, Landry and

Beyroux; No. 51, Dion tricycle; No. 13, Dion tricycle; No. 42, Delahaye; No. 30, Maison Parisienne; No. 7, Panhard and Levassor; No. 39, Bollée tandem; No. 9, Lebrun.

The vehicles were sent on their way in the presence of enormous crowds of people who had taken the greatest interest in the new carriages, and this interest was of an eminently practical character, for some of the makers booked a large number of orders from buyers who were anxious to complete negotiations there and then. The run to Avignon, a distance of 109 kiloms., took place with no other incident than a collision of the No. 7 Panhard and Levassor vehicle with an ordinary carriage, at which the horse suddenly swerved round at the approach of the petroleum car. As this vehicle had already lost a great deal of time through being overturned at Villefranche, M. Levassor decided upon withdrawing it from the race, and it was sent on to Paris by train. The first two vehicles to complete this stage were the Dion tricycles, of which the No. 51 did the distance in 3 h. 36 min. 55 sec. Then came the No. 6 Panhard and Levassor and the No. 46 Peugeot, which arrived almost together. During the run from Avignon to Lyons, a change took place in the position of the vehicles, for the head wind was so strong that the riders of the tricycles had to use their pedals nearly all the way, and were, consequently, utterly exhausted. The Panhard and Levassor vehicles then took the lead, and No. 6 arrived first at Lyons, having covered the 227 kiloms. 800 meters in 8 h. 21 min. 10 sec. On the aggregate time, the No. 8 was leading, being 2 min. ahead of No. 6, and 42 min. in front of the No. 46 Peugeot. Between Lyons and Dijon the Peugeot carriages continued to meet with a great deal of hard luck. They had lost much time through the extinction of the burners, and now No. 44 came to grief through a derangement of the steering gear, and about three hours were lost in doing the necessary repairs. No. 46 also stopped to allow of a slight defect in the mechanism being put right. Meanwhile the Panhard and Levassor vehicles continued to secure the honors of the different runs, and No. 6 was the first to reach Dijon, having covered the 198 kiloms. in 6 h. 35 min. The second was No. 8 carriage of the same firm, and this was followed by No. 42 Delahaye, and by the two Dion tricycles. No. 6 continued its triumphal run on the ninth stage from Dijon to Sens—209 kiloms.—and at the end was leading by half an hour, so that victory seemed to be morally certain. It covered the distance between the two towns in 7 h. 4 min., followed by Nos. 5 and 8 of the same firm. It is to be noted that on the return journey, so far, only one carriage had been put out of the race, and this was not due to any inability of the carriage to continue the struggle. At the same time it must be remembered that all the vehicles carried workmen to effect repairs, so that though several of the carriages lost considerable time through accidents, they were yet able to complete the journey. Had it not been for the precaution of makers to arrange for the prompt carrying out of repairs, it is certain that the number of disabled vehicles would have been much greater. As the number of vehicles left in the race was larger than had been expected, a lively interest was taken in the arrival of the competitors in Paris on Saturday. At midday a considerable crowd assembled at the Porte Maillot, and it was curious to notice the number of private petroleum carriages that lined the avenue. The first vehicle to make its appearance was No. 51 tricycle, which had covered the 120 kiloms. in 4 h. 55 min. The rider received a splendid ovation, and the cheering was redoubled when the two Panhard and Levassor carriages—Nos. 8 and 5—arrived at the end of the journey. Then came the Bollée tandem and No. 41 Delahaye followed by the two Peugeot carriages and No. 6 Panhard and Levassor, the last named having lost half an hour on the road through something going wrong with the steering gear. Altogether, fourteen vehicles arrived in Paris, so that the result of the second half of the race must be held to be satisfactory.

The times occupied in covering the entire distance of 1,728 kiloms.—about 1,073 miles—are as follows:

No. 6, Panhard and Levassor, 67 h. 42 min.; No. 8, Panhard and Levassor, 68 h. 11 min.; No. 13, Dion tricycle, 7 h. 1 min.; No. 5, Panhard and Levassor, 71 h. 23 min.; No. 51, Dion tricycle, 73 h. 30 min.; No. 46, Peugeot, 75 h. 26 min.; No. 41, Delahaye, 75 h. 29 min.; No. 44, Peugeot, 81 h. 23 min.; No. 15, Dion tricycle, 83 h. 6 min.; No. 42, Delahaye, 84 h. 27 min.; No. 29, Maison Parisienne, 100 h. 41 min.; No. 30, Maison Parisienne, 108 h. 39 min.; No. 26, Landry and Beyroux, 137 h. 11 min.

The prizes are distributed as follows:

For carriages with two to four places: First, No. 6, Panhard and Levassor; second, No. 8, Panhard and Levassor; third, No. 5, Panhard and Levassor; fourth, No. 41, Delahaye; fifth, No. 44, Peugeot; sixth, No. 42, Delahaye; seventh, No. 29, Maison Parisienne; eighth, No. 30, Maison Parisienne; ninth, No. 26, Landry and Beyroux.

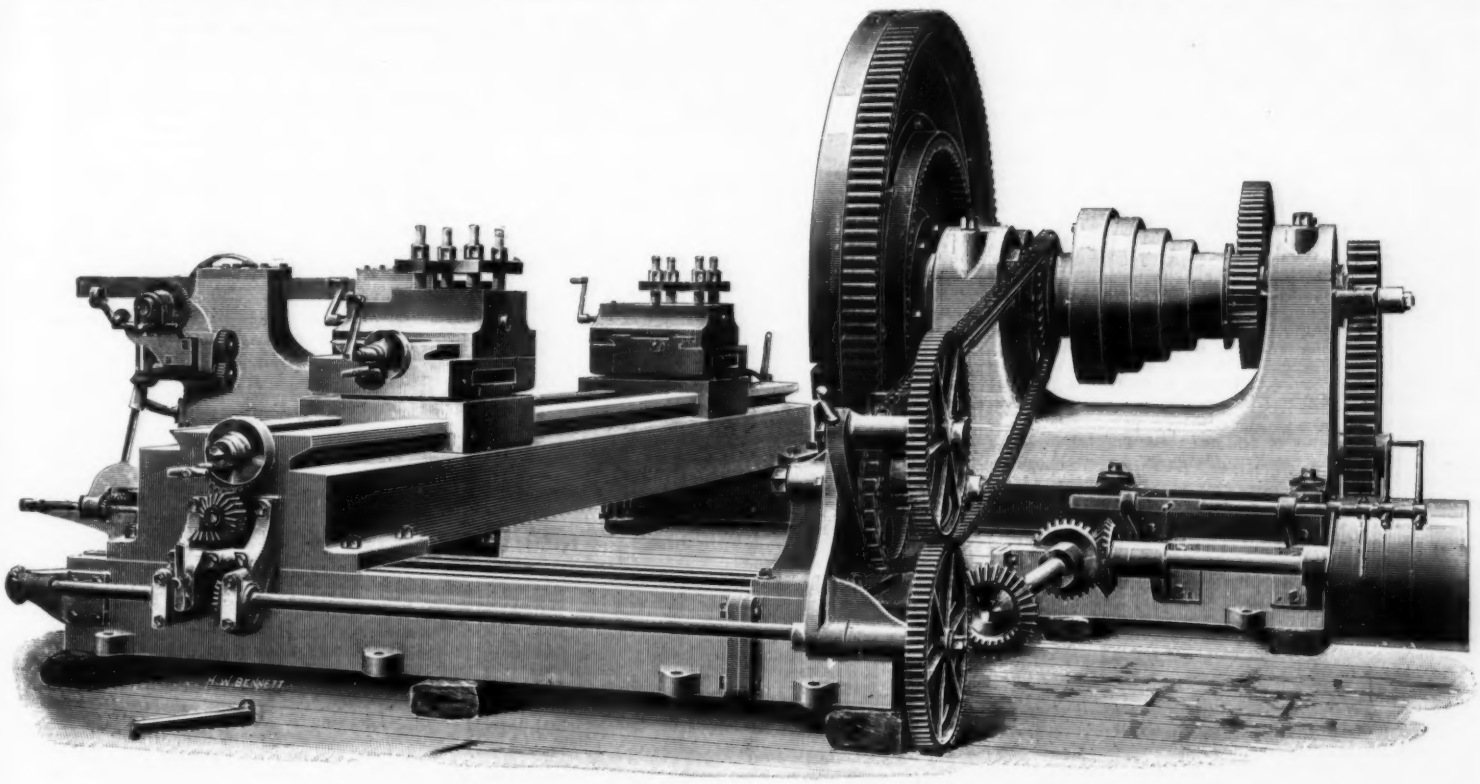
For carriages with more than four places: First, No. 46, Peugeot. For motor cycles, first, No. 13; second, No. 51; third, No. 15.

The first thing that strikes one in summing up the results of the race is the complete success of the vertical motor for light carriages. Whether this victory is a convincing proof of the superiority of the vertical type of motor is open to doubt. A race of such long duration and run off under such trying conditions as prevailed during the first half of the journey is hardly a fair test of the capabilities of the mechanical vehicles as a class, and it would have been much more satisfactory to have submitted the carriages to trials organized with a view of bringing out all the qualities and defects of the various motors, and not the single one of speed, necessitating as this does the reckless driving of the mechanism at its maximum power. As arranged, the question of luck entered much too largely into the race to enable one to draw definite deductions from the results, or, if it were not luck, then it must have been the smartness and cleverness of the drivers. Had all the competitors equally good fortune in avoiding the obstacles that brought so many of them to grief, it is fairly certain that the placings would have been modified, while a great many more would have finished the entire journey. As it is, the failure of so many competitors through causes that had nothing to do with the mechanism of the vehicle itself makes the racing test untrustworthy, and the conclusions to be drawn therefrom are necessarily somewhat imperfect. There are, however, certain points that come out very clearly from this race, and these are suggested by the state of the vehicles when they had completed the journey. The carriages themselves had undergone surprisingly little wear and tear, and the No. 5 Panhard and Levassor, which had been overturned by a dog, had sustained no other damage than a dent in the fore part of the vehicle and the bending of the lamp and the mud guard. The tires, however, were cut all to pieces, and had to be tied on by wire.

The flat India rubber tires of these carriages are cemented on to the rims, and they are quite useless for carriages running at a high rate of speed. According to some experts, it is the speed of the vehicle that exercises such a destructive effect upon the tires, and India rubber will not stand the work put upon it by continual fast running. The pneumatic tires also punctured repeatedly, and it is evident that much will have to be done before this part of the carriage can give entire satisfaction. Then the condition of the carriages and of the passengers themselves suggests that something is needed to secure greater cleanliness in the mechanical vehicle. The oil and petroleum spirit which filter from the mechanism on to various parts of the carriage gather up the dust in such a way as to make the vehicle almost unrecognizable. In the carriages this is not of so much importance as in the Bollée tandems, where the riders are brought in actual contact with the oily dust, and the destruction of one's clothes is inevitable. In either case it is very desirable that the overrunning of oil and petroleum spirit should be avoided, and in private carriages, of course, this is done by thoroughly cleaning them as often as possible. Another thing shown up by the race is the trouble caused by the firing tubes, which, in the case of Peugeot, undoubtedly prevented their occupying a more prominent place at the finish. In the high wind the burners went out repeatedly, and the carriages were being constantly stopped. No doubt the firing tubes are more certain in their action so long as they can keep alight than the electrical battery, but electricity has the enormous advantage of never being affected in the slightest degree by the weather. As to constructional details, the race will probably have shown makers the uncertainty of the present systems of steering gear. It is only quite lately that manufacturers have really given any serious attention to this matter, and the accidents resulting from imperfect steering may probably result in some improvement in the present methods. The race may be said to have entirely served its purpose of pointing out to makers the weak points of their vehicles, though on the whole it has merely confirmed the results of previous trials, without throwing much new light upon the mechanical carriage.—The Engineer.

A LARGE FACING AND BORING LATHE.

THE powerful surfacing and boring lathe shown in the accompanying engraving was built by Messrs. Shepherd, Hill & Company, Limited, of Leeds, England. It is capable of turning and boring simultaneously castings up to 18 ft. in diameter and 5 ft. in depth. The machine has been built with a double and treble gear fast headstock, with 42-in. centers, and carrying a large faceplate, which is fitted at the back with both external and internal wheels. The cross slide carrying the tool post saddles is 21 ft. long and very strong and deep. The center of this cross slide is also supported from the bottom of the pit. The compound slide rests which ride on this cross slide can be fed either automatically or by hand for both parallel and taper work. A feed of as much as ¼ in. per revolution can be obtained from the "self-acts" when required. The boring head is lipped in and securely bolted to the cross slide, and travels with it when opening or closing the gap. It carries a 5 in. square steel sliding spindle, operated either by hand or self-acting feed, and has a quick return motion arrangement for speedily withdrawing the tool. The cross slide is traversed on its beds by power and can be moved at the rate of 6 ft. per minute. The complete machine weighs 40 tons, and when erected was bolted down to heavy foundation beds.



FORTY-TWO INCH SURFACING AND BORING LATHE.

We are indebted for our illustration and particulars to the courtesy of Engineering.

THE Sibley Journal of Mechanical Engineering gives the results of some experiments to determine the comparative holding power of wire and cut nails. The tests were made on pieces of white pine, joined with simple lap joints fastened by the nails. These were subjected to transverse stresses, in some cases parallel to the axes of the nails, in others at right angles. When the load was applied perpendicular to the nails, the wood was often split and the cut nails were often broken, while the wire nail joints were broken by bending and drawing the nails. When the load was applied in the direction in which the nails were driven, the joints were broken by nails being drawn almost without being bent. Under this same manner of loading, the nails were started by smaller loads than the cut nails, yet when the cut nails were started they yielded rapidly, while the wire nails held nearly as well as at first. In all the cases tried the cut nails were found superior in strength and rigidity, while in one-half the cases wire nails gave the joints greater resilience than the cut nails.

ENGINEERING NOTES.

It is said that an English motor car manufacturer is building a two-story steel house to run on wheels, propelled by a motor under it. The top story is collapsible, so as to enable the house to pass under bridges. We cannot, however, vouch for the truth of the statement.

The use of motor cars in connection with street scavenging has been discussed by the Dover town council, and the arguments in favor of horseless vehicles were so strong that the council decided to delay the erection of extensive stabling accommodation on land they have purchased for a scavenging depot pending further information.

An apparatus for the prevention of smoke has been efficient at the Paris Opera House and in some other buildings. The combustion products of several fires may be passed through the apparatus, which also sends the gases into an inverted funnel opening under water. Above the water is a bell, in the upper part of which the discharge pipe starts, descending and rising. The gases may be discharged directly into the atmosphere, or they may first be utilized.

Germany's fastest long distance train is the Ostend-St. Petersburg, which runs 881 miles over German territory in twenty-two and a half hours, a mean speed, including stops, of 39·1 miles an hour. On the return journey better time is made, the rate then being 40·6 miles, or, in actual running time, excluding stops, 43½ miles. The train between Berlin and Hamburg, however, makes 176½ miles in 3 hours 36 minutes, the mean speed being 49·1 miles an hour.

For the cutting speed of milling cutters in good German practice the following rule is given by the American Machinist: Revolutions per minute = C ÷ diameter of the cutter in inches. The value of C varies with the material. For cast iron or cast steel C = about 300, for wrought iron 200 to 240, for hard brass 320 to 340, and somewhat greater for soft brass. The resulting speeds are: For cast iron and cast steel 52 ft. per minute, for wrought iron 52 to 62, and for hard brass 62 to 89. The feed per minute for cast iron, wrought iron or steel is from 0·6 to 1·2 in. and for brass 2 in. or more. The classing of cast iron and steel together may seem strange, but probably a lubricant is used for steel and not for cast iron.

The French Revue Industrielle says that probably the swiftest vessel in the world is the seagoing torpedo vessel constructed at Havre by the well-known house of Augustin Normand, the contract requiring that it should maintain a speed of twenty-nine to thirty knots an hour under full steam. At its trial trip, it seems, this vessel, the Forban, ran a distance of more than thirty-one knots in an hour, this being equivalent to about thirty-five miles, probably the greatest distance ever covered by a seagoing ship in sixty minutes—powerful engines being necessary, of course, to drive the vessel through the water at such a rapid rate. Although the displacement of the craft is only about one hundred and fifty English tons, it carries engines of 3,250 horse power.

One of the largest wheels ever cast in one piece has just been turned out of the works of Thomas Firth & Sons (Limited), Sheffield, England, says the Engineering and Mining Journal. It is of cast steel, and is intended for the rail mill of the Ebbw Vale Steel and Iron Company. It is 12 ft. 6⅜ in. in diameter, 9 in. pitch, 32 in. wide, and weighs 18½ tons. It has a set of double helical teeth. The whole mass was cast without a hitch. The wheel is the heaviest ever cast in one piece at the Norfolk Works, and ranks among the largest ever cast in the kingdom. Messrs. Firth & Sons are now at work on a wheel of much larger diameter, but not of such great weight, and they are also casting an immense hammer block, which, when completed, will weigh 25 tons.

The Monthly Bulletin of the Bureau of American Republics for June has an article on the railway systems of the Argentine Republic, in which the total railway mileage is given at 14,029 kilometers (about 8,760 miles); of this total, five lines are the property of the nation, with a length amounting to 1,026 kilometers; ten lines with a total length of 3,834 kilometers are guaranteed by the government; seven lines of 6,241 kilometers are without national guarantee, and seven lines, comprising 2,928 kilometers, are subject to provincial jurisdiction. In 1894 there were in service 1,112 locomotives, of which 868 were of English manufacture, 144 American, 68 French, 12 Belgian, 9 Canadian, 2 German and 4 of home manufacture. There were 1,456 passenger coaches, of which 824 were of English manufacture, 235 American, 184 Argentine, 92 French and 121 the manufacture of which is not given. There were 31,039 freight cars, 17,940 of which were of English make, 6,421 Argentine, 1,496 American, 1,265 French and 3,917 not stated.

The value of a pound of coal at different epochs in steamship evolution has been stated in a striking form by Mr. A. J. McGinnis, president of the Liverpool Engineering Society. In 1840 a pound of coal propelled a displacement weight of 0·578 ton eight knots; but the earning weight was only one-tenth of this, as 50 per cent. of the displacement represented the machinery and fuel, 40 per cent. the hull, and 10 per cent., or 0·057 ton, the cargo. In 1850, with iron vessels and the screw propeller, a displacement weight of 0·6 ton was propelled nine knots by a pound of coal; but the proportion of cargo had risen 27 per cent. or 0·16 ton. In 1860, with higher boiler pressure and the surface condenser, 0·82 ton displacement was propelled ten knots, and the cargo was 33 per cent. or 0·27 ton. In 1870 the compound engine was in full swing, and 1·8 tons displacement was propelled ten knots, and the cargo was 50 per cent. or 0·9 ton. In 1880, in the freight steamer, 2·1 tons displacement were propelled ten knots, with still 50 per cent. or 1·5 tons of cargo. In 1895 there were two classes of freight boats. The "tramp" (working better than the tramp on land) propelled 3·4 displacement tons eight and one-half knots, with 60 per cent. or 2 tons of cargo. At the same time the huge cargo steamers of the North Atlantic were driving a displacement of 3·14 tons twelve knots with 55 per cent. or 1·7 tons of cargo. On the express passenger steamers the cargo weight is down to 0·09 ton per pound of coal.

ELECTRICAL NOTES.

Electric lights have been inserted in the cornice of the small rotunda of the great dome of the Capitol at Washington, D. C.

The Russian ministry of ways and communications is reported to have resolved to try at once a series of experiments with electric railways on the St. Petersburg and Moscow lines and the St. Petersburg and Warsaw lines and on the lines running to the Baltic provinces.

Prof. Ayrton, in discussing Mr. Preece's British Association paper on "Electric Glow-Lamp Tests," stated that he had been testing a new lamp, not yet on the market, the filament of which was carbide of silicon. He spoke eulogistically, says Electricity, of this lamp, and stated that after a life of 1,000 hours the consumption did not exceed 3·75 watts per candle.

It is said that the Fitchburg Railroad is contemplating running trains through its long Hoosac Tunnel by electricity. There is abundant water power in the vicinity, so that the cost of operation would not be very great, and the doing away with the dust and smoke would add greatly to the popularity of the route. Several years ago it was lighted by electricity.

M. Bouvier, in a report to the French Postal Department in Tonquin, states that the service has been much disturbed by the breakdown of their subterranean lead-covered cores, due to the attacks of white ants. The cable, although laid in very good condition in July, 1894, showed signs of loss of insulation early in 1895 and had to be entirely replaced in 1896.

The first central telephone station of Berlin, opened in 1881, connected 33 subscribers. At the end of 1894 there were 28,450 subscribers in Berlin and suburbs. On January 1, 1895, there were more than 33,000 kilometers of overhead wires and more than 18,000 under ground. Berlin has now telephonic communication with 234 different localities.—Uhland's Wochenschrift.

An exhibition will be held early next year at Newcastle-on-Tyne. The object will be to show the latest inventions in every branch of the engineering trades and industries, and to accentuate the progress which has been made in electric engineering between the years 1837 and 1897. It is intended also to make a special feature of cars and cycles propelled by electric or other motor power.

Mr. W. M. Mordey exhibited at Section A meeting of the British Association an instrument for measuring magnetic permeability. The instrument consists of a laminated iron yoke of horseshoe form, the magnetic circuit being completed within about one-tenth of an inch by the sample under test. The magnetizing coil surrounds the test piece, and the magnetic field in the air gap is measured by the force which it exerts on a copper strip conveying a current.

A curious fact connected with deaths by lightning has recently been noticed in Europe. It appears that, as compared with the country, towns, and especially cities, possess remarkable immunity from lightning strokes. The statistics which have been compiled on the subject show that between 1800 and 1851 there was not a single death by lightning recorded in Paris, and that only one person out of each million that die in London is taken off by a discharge from nature's electric battery. Between 1851 and 1895 only three persons were struck by lightning in Paris, and only one of these three cases resulted fatally. In Berlin only five persons have been struck by lightning since 1713.—College and Clinical Record.

A railway based on the Greathead system of tunnels is now proposed for Brussels. It is to be worked by electricity and to run fifty feet below the surface. The first portion is to consist of a complete circle about four miles long, with double track, having eleven stations, and a future extension of a second circle about two miles long, with four stations. The two tunnels for the different directions will be quite distinct from each other; they run almost entirely below the public streets. The subsoil appears to be clay. There is to be a two and one-half minute service each way. The total cost of the first circle is estimated at $3,000,000, a less rate than the City and South London line, which cost $1,000,000 per mile. The elevators are to be operated by hydraulic power and will hold forty people.

At the recent meeting of the British Association, says the Electrical Engineer, Mr. W. H. Preece stated in the course of the discussion on Prof. Chunder Bose's paper on "Electric Wave Apparatus," that a young Italian, Signor Marconi, had described experiments in which he had, by means of Hertzian waves, transmitted signals over a considerable distance, and as a result Mr. Preece had assisted Signor Marconi to continue his experiments in London and on Salisbury Plain. Signor Marconi has now succeeded in producing electric waves and reflecting them from one parabolic mirror to another, one and a quarter miles distant, the waves falling on a receiving apparatus, which actuated a relay and produced Morse signals; the experiments have been made with crude apparatus and without employing any great amount of radiant energy.

With the systems of measuring the velocity of projectiles at present in vogue, it is necessary to employ screens, which are broken by every shot and must be replaced or mended every time a shot is fired. This, of course, is very troublesome, as it involves sending a man along the range after every discharge to attend to the screens. All this is done away with by a new system invented by Dr. Purcell Taylor, of London. He has perfected a screen which is perpetually ready and automatically adjusts itself after every shot in preparation for the next one, while it is rather quicker in action than the old screens. Dr. Purcell Taylor has also perfected a continuously registering chronograph, somewhat after the pattern of the one he brought out four years ago, with the principle of which he was not satisfied, although the few sold answered every expectation. With the new chronograph and screens it is now possible to take velocities at the muzzle, at the target and at any number of points between them, and all this while you may be peacefully slumbering in the chronograph house. It will also take velocities on continuous discharges of a machine gun. The convenience of these improvements will commend them to ordnance and ammunition manufacturers.

MISCELLANEOUS NOTES.

A young woman who descended from a balloon with a parachute at Cardiff recently was carried out into the Bristol Channel and smothered in the soft mud in which she came down.

England's nickel trade is passing through a severe crisis, owing to the diminished consumption of the metal in German coinage and the competition of the French Nickel Company, which has reduced the price from $4 a pound to 27 cents.

There are 371¼ grains of pure silver and 41¼ grains of copper alloy in the American standard silver dollar, and 23·22 grains of pure gold and 2·58 grains of silver and copper alloy in the gold dollar. The full weight of the gold dollar is 25·8 grains, and the silver dollar is 15·98 times as heavy, or 412½ grains.

Russia has 503,000,000 acres of forests. In Sweden and Norway the forest area covers 62,000,000 acres; in Austria, 45,000,000 acres; in Germany, 34,000,000 acres; in Turkey, 25,000,000 acres; in Italy, 14,000,000 acres; in Switzerland, 1,700,000 acres; in France, 22,000,000 acres; in Spain, 8,000,000 acres; in Great Britain, 3,000,000 acres.

Policemen in Paris now carry clubs, beautifully decorated. They are pure white, with yellow handles. Around the middle is painted a double blue ribbon, with the city arms at the point where the ends of the ribbon cross. The white color will be more easily noticed than any other by coachmen, the sticks being held like conductors' batons by the policemen in the middle of the street, to direct travel to the right or left or to stop it when needful.

Laboratory crucibles, capsules and tubes, of very thin porcelain, so that they withstand, without cracking, sudden variations of temperature, are made at Bayeux, France, from kaolin obtained in the Commune des Pieux, near Cherbourg. The factory, transformed in 1810 from an ancient Benedictine convent, was reorganized in 1883 by the Messrs. Morlent, who introduced mechanical appliances for preparing the clay, mixing the paste and forming the various articles.

The year book of the United States Department of Agriculture for 1895 contains a general report of the operations of the department; a series of papers prepared in the different bureaus and divisions of the department, or by experts specially engaged, and designed to present in popular form results of investigations in agricultural science or new developments in farm practice; an appendix of 104 pages, containing miscellaneous information, and agricultural statistics compiled down to the latest available date, relative to the production, values, per capita consumption, exportation and importation of farm products. Of the edition of 500,000 copies, over 1,000 copies are allowed to each member of Congress for distribution among constituents.

Says an English correspondent: The oldest tree in this country is the yew tree at Braburn, in Kent, which is said to be 3,000 years old, while at Fortingal, in Perthshire, is one nearly as old. At Ankerwyk House, near Staines, is a yew tree which was famous at the date of the signing of Magna Charta, 1215, and later was the trysting place of Henry VIII and Anne Boleyn. The three yews at Fountain Abbey are at least 1,200 years old, and beneath them the founders of the abbey sat in 1132. There are no famous oaks that rival any yew in age, 2,000 years being the greatest age attained. Damorey's oak, in Devonshire, which was blown down in 1703, had this distinction. Cowthorpe oak, near Wetherby, Yorkshire, is said to be 1,600 years old.

For some years inventors have been trying to transport fruit in cars filled with carbonic acid gas, says Garden and Forest. Inasmuch as the germs of fermentation cannot live in this gas it is assumed that no ice would be needed, and since this is both heavy and expensive, it is thought that fruit can be transported for long distances much more cheaply in the new way. A carload of fruit in one of these gas cars was lately sent from San José, California, to Chicago, but the result was not satisfactory. It is reported in the local papers that the fruit had not rotted, but, owing to the extreme hot weather, it had almost been cooked. Ice will still be a necessity in very hot weather unless some means of keeping the car cool is added to the antiseptic advantages of the gas.

The last new craze in Paris is said to be the wearing of a lighted lantern as a personal ornament. The fashion has not been adopted in honor of M. Rochefort, the once dreaded Lanterne man, but originated with a speculative manufacturer, whose petites lanternes were bought by tens of thousands at the fair of Neuilly. The lantern is very small and neat, and made in a Gothic form after an ancient model; it is only of tin, but is sufficiently solid; it has well-fitted glass plates, is about the size of a walnut, burns for some hours, and is sold at the price of six sous. Almost everybody who returned from the fair to Paris recently, as a correspondent tells us, looked as if he were outwardly symbolizing the Midsummer Saint, John the Baptist, "a burning and shining light." The men and boys wore the little lanterns in their hats, and the ladies carried them in their bouquets.—Westminster Gazette.

In Paris, where wood has been to a large extent substituted for asphalt and other paving material, southern pine is very largely used for blocks, says Garden and Forest. These are laid on a concrete foundation, and, as is well known, the streets are less noisy and the pavement is considered more durable than any other. It would seem that if yellow pine pavement is the best for Paris, where public works are constructed with a view to the greatest economy, combined with utility, the same material could be used in America, especially in our Southern cities. Experiments with wood pavements in New York and Chicago have been discouraging, but it may be that the fault was as much in the construction as in the material. In a climate where the ground freezes to the depth of 3 or 4 ft. the foundation of the road would be unsettled to a degree unknown in London or Paris, and this upheaving may suffice alone to account not only for the stability of roadways but of walls in England, which endure for centuries, while they crumble and tumble here when only a few years old.

SELECTED FORMULÆ.

Wild Cherry and Orange Phosphates.—A satisfactory wild cherry phosphate has been made by adding to the solution of acid phosphates of the National Formulary a small quantity of extract of wild cherry. The exact quantities necessary to flavor a gallon of sirup you can easily determine by a few experiments. Dubelle gives the following formula for wild cherry phosphate:

Pure wild cherry sirup	6 pints.
Pure grape sirup	1 "
Sherry wine	1 "
Acid solution phosphates	8 fluid ounces.

The acid solution of phosphates is made as follows:

Potassium phosphate	1¼ drachms.
Magnesium phosphate	2⅝ "
Sodium phosphate	1⅓ "
Calcium phosphate	4 "
Orthophosphoric acid	8 fluid ounces.
Water enough to make	8 pints.

Here is a formula from Bonham's Guide for wild cherry phosphate sirup:

Essence bitter almond	10 drachms.
Acid phosphate	12 ounces.
Fruit acid	1 "
Simple sirup	3 quarts.
Caramel coloring	1 drachm.
Cochineal coloring	¼ "

Another formula from the Spatula, and which contains no phosphate, is this one: Fluid extract wild cherry, 2 drachms; tincture cudbear, 2 drachms; port wine and spirits Cognac brandy, of each, 4 drachms; fruit acid, 2 drachms; add to all mixed a sufficient quantity of sirup to make one quart.

ORANGE PHOSPHATE.

Essence of orange (1-8)	.1 to 4 fluid drachms.
Solution acid phosphates	12 ounces.
Solution citric acid (50 per cent.)	1 "
Caramel coloring	1 drachm.
Cochineal coloring	15 minims.

The quantities given are sufficient to flavor one gallon of sirup.

Here is a formula for blood orange phosphate:

Raspberry juice	6 ounces.
Extract orange	1½ "
Fruit orange	⅔ "
Sirup	¾ "
Red coloring, enough.	1 gallon.

The addition of raspberry juice improves the orange flavor. The acid phosphate (one drachm) is added when the drink is served.—Confectioner's Journal.

To Test the Purity of Vaselin.—Vaselin (as Europeans generally, but incorrectly, term petrolatum) is said to be adulterated occasionally with fatty matters of animal or vegetable origin. MM. Crouzel and Dupin, in the Moniteur des Produits Chimiques, give the following simple method of demonstrating such adulteration when it exists: Triturate 5 grammes of the suspected vaselin with 5 to 10 grammes of potassium permanganate. If the material is pure, the rose coloration is persistent, but otherwise it becomes chestnut brown, the depth of color being in direct ratio to the amount of falsification.

Painless Extraction of Teeth.—D. Frohmann (Med. Week., iv, p. 312) recommends the following solution:

Cocaine hydrochlorate	10—20 ctg.
Morphine hydrochlorate	25 mg.
Sterilized sodium chloride	20 ctg.
Antipyrine	1—2 gm.
Guaiacol	2 drops
Distilled water	100 gm.

For external use.

A few drops of this solution are injected into the gum at various points around the teeth to be extracted, and at a certain distance therefrom, until it appears pale, when the tooth may be extracted without pain. The object of adding morphine and antipyrine is to prevent the pain that frequently supervenes when a tooth has been extracted under cocaine anæsthesia as soon as the analgesic effect of this alkaloid has passed off.—Merck's Report.

To Color Benzine Red.—Benzine may be colored red by dissolving in it a sufficient amount of red aniline hydrochlorate, the depth of color depending of course upon the quantity of the coloring agent used. Alkanet may also be used for this purpose, but has the disadvantage that it fades on long exposure to light.

Diamond Cement.—The following formula will be found useful in repairing china, glass, wood, leather, etc.:

Isinglass	240 grains.
Mastic	120 "
Gum ammoniac or galbanum	60 "
Alcohol	4 fluid ounces.
Water	4 " "

Soak the isinglass in the water for twenty-four hours; evaporate on a water bath to 2 fluid ounces; then add 2 fluid ounces alcohol; strain; add the mastic dissolved in the remaining alcohol; and add the ammoniac by trituration, avoiding loss of alcohol as much as possible.—Bulletin of Pharmacy.

A Remedy for Thirst.—Thirst and great dryness of the mouth in sickness is often relieved by a teaspoonful of powdered gum arabic, beaten thoroughly with two teaspoonfuls of glycerin, to which is added a glass of cold water and enough lemon juice to make the mixture palatable. The mixture may be taken freely, with great relief to the dryness of the mouth and thirst.—Medical Times.

Cement for Leather.—

Strong glue	50 parts.
Water	q. s.
Turpentine	2 parts.
Starch paste	100 "

Dissolve the glue over the fire in the water; add the turpentine, stir up well and mix with the starch paste while hot.—British and Colonial Druggist.

CONSTRUCTION OF A TESLA-THOMSON HIGH FREQUENCY COIL.*

By Prof. A. F. McKISSICK.

THE following is a description of the construction of a Tesla-Thomson high frequency coil, large enough to give a five inch spark and excite Roentgen ray tubes.

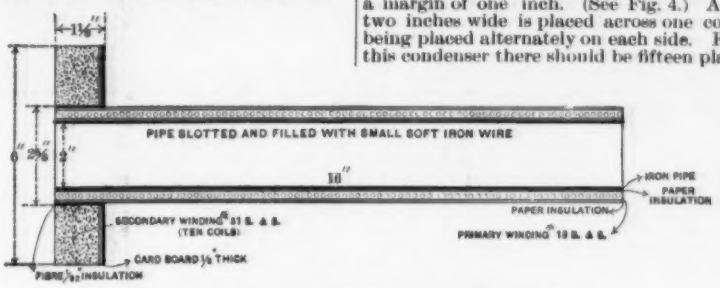


FIG. 1.—HIGH TENSION TRANSFORMER.

To excite the Tesla-Thomson coil, a high potential transformer of from 10,000 to 15,000 is necessary. The construction of this transformer will be first given. Fig. 1 gives a partial cross section of the transformer, which is made as follows: A two inch iron pipe, sixteen inches long, is slotted the whole length, either in a

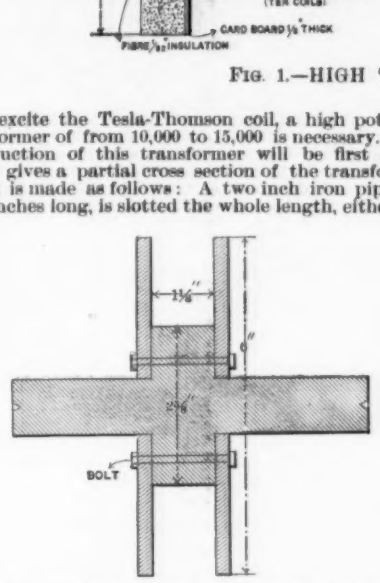


FIG. 2.—FORM FOR WINDING COILS.

milling machine, planer or shaper. This slot need not be more than ⅛ inch in width. The pipe is then insulated with ordinary wrapping paper to an outside diameter of 2⅛ inches, shellac being freely used, and is then wound with No. 13 B. & S. double cotton covered wire for its whole length (one layer). It is then covered with paper and shellaced until the outside diameter is 2⅝ inches.

The next step is to fill the pipe with soft iron wires, No. 16 B. & S., each wire being cut eighteen inches

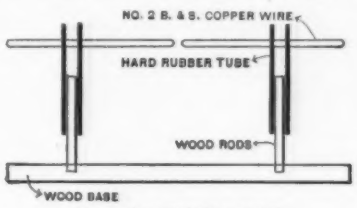


FIG. 3.—SPARK GAP.

long. This completes the primary winding of the high tension transformer.

The secondary winding of this transformer consists of ten coils wound in a form and thoroughly taped and insulated. This form is shown in Fig. 2, and can be easily made of wood. The wire is wound in this form,

The spark gap (see Fig. 3) is made as shown in diagram. The copper wires fit rather close in the holes drilled through the hard rubber tubing, so that the length of the gap can be adjusted with ease.

The condenser is made of ordinary 10 inch × 12 inch window glass. A sheet of tinfoil 8 inches × 10 inches is pasted on one side of the glass with shellac, leaving a margin of one inch. (See Fig. 4.) A strip of tinfoil two inches wide is placed across one corner, this strip being placed alternately on each side. For each side of this condenser there should be fifteen plates.

To build this condenser proceed as follows: Place on a smooth surface a condenser plate with the connecting strip projecting on the right. On top of this plate place another piece of glass, 10 inches × 12 inches, that has no tinfoil on it at all. Then place a condenser plate with the strip projecting on the left. Then a

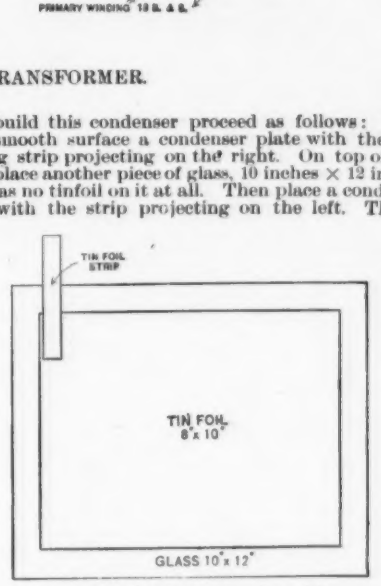


FIG. 4.—CONDENSER PLATE.

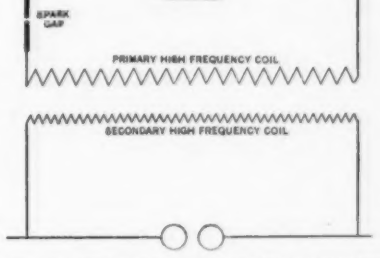


FIG. 6.—DIAGRAM OF CONNECTIONS.

piece of glass without tinfoil, and on top of this a condenser plate with the strip projecting on the right, and so on. This construction gives two thicknesses of glass between each sheet of tinfoil, which is absolutely necessary.

The high frequency coil is made as follows: Wind

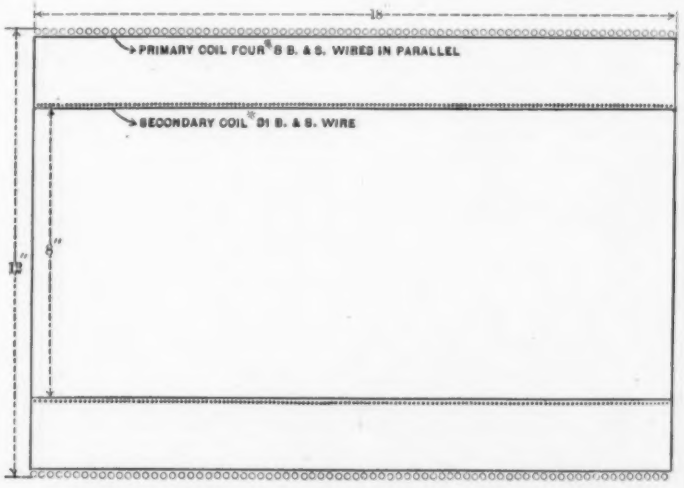


FIG. 5.—PRIMARY AND SECONDARY COILS OF HIGH FREQUENCY TRANSFORMER.

shellaced, removed, taped and baked. These coils are then slipped over the primary winding, between each coil being placed a disk of cardboard ⅛ inch thick, care being taken to connect the coils so that none will be in opposition.

an eight inch paper cylinder eighteen inches long with No. 31 B. & S. double cotton covered wire (or larger), leaving a margin at each end of about 1 inch. This is the secondary winding. The primary winding is placed on a 12 inch paper cylinder 18 inches long, and consists of 14 turns of 4 No. 8 B. & S. double cotton covered wires in parallel. Each of these No. 8 wires is wound on separately, then the four ends at the beginning and

* For the article and engravings we are indebted to the American Electrician.

ending are soldered together. Between wires of different polarity, as an extra precaution, two turns of cord are wound. The primary and secondary coils are then shellaced and baked. After being baked, the secondary coil is placed concentrically (see Fig. 5) inside the primary and the connections as shown in Fig. 6 then made.

The primary of the high tension transformer must be excited with an alternating current. With a frequency of 60 cycles per second 50 volts will suffice, and for 125 cycles per second 100 volts. The length of the spark from the secondary of the high frequency coil will depend on the width of the "spark gap;" consequently, in exciting a tube it is best to start with the "spark gap" very short, then gradually increase until the tube is properly excited. When the terminals of the secondary high frequency coil are separated farther than five inches, a spark will pass from the secondary to the primary of the high frequency coil. By the use of a good insulating oil a much longer spark can be obtained from the high frequency coil, but for exciting Roentgen ray tubes a five inch spark will be sufficient.

[Continued from Supplement, No. 1085, page 17361.]

ALTERNATE CURRENT TRANSFORMERS.*

By Dr. J. A. Fleming, F.R.S.

Lecture III.

THE TESTING OF TRANSFORMERS.

Having considered the action and construction of transformers, our next duty is to notice the principal facts connected with the testing of transformers. This is a matter of considerable importance. It is not too much to say that in very few alternating current stations is there any proper system of purchasing transformers to a rigid specification, and enforcing delivery to this specification by efficient methods of electrical testing. Engineers appear to be far too often quite content to accept manufacturers' figures without any confirmation. As an instance of the possible consequences of such a course, I may mention that not long ago I had occasion to specify for two transformers on behalf of a corporation. The core loss of these transformers was to be not greater than 350 watts when measured at the proper primary pressure and on open secondary circuit. When the transformers were delivered they were tested. One of them was found to comply with the specification, the other took up 1,000 watts under the same circumstances. As these transformers were 30 kilowatt transformers, intended to be worked in a substation, and to be connected with the mains for at least 4,000 hours in the year, it is perfectly clear that if no test had been applied, and if the transformers had both been accepted, one of these transformers would have taken up 500 watts more than the other. This additional core loss, proceeding for 4,000 hours in the year, would have meant an addition to the magnetizing losses of 2,000 Board of Trade units per annum. As this would have involved an expenditure in coal and water of at least one penny per unit, the facts, translated into money, mean that one transformer would have cost something like £8 per annum more than the other to maintain magnetized. If this is capitalized at only 3 per cent., it means £240, whereas the actual cost of the transformers did not exceed £140 each. It is clear, therefore, that the omission of a systematic process of testing transformers and of specifying for them for test may involve a supply company or corporation in an increased annual expenditure for maintenance, which under some circumstances may even amount to a considerable sum.

In dealing briefly with the subject of testing transformers, I shall not attempt to describe all the many different methods which have been suggested, but confine myself shortly to one which is simple, direct, and can be applied in any substation or workshop. It should always be remembered that although an electrical method may theoretically give the required result, yet practically it may be difficult to get good results with it on account of the fact that to obtain the necessary accuracy we must assume an unattainable precision in some of the measurements. The method which, after long experience in this matter, I have found most applicable in all ordinary cases is one depending on the employment of a properly constructed wattmeter, standard power absorbing resistance, and an auxiliary transformer. We will discuss, in the first place, the construction of each of these instruments separately. If an alternating current is sent through a fixed coil of wire and another current through a movable coil suspended with its magnetic axis at right angles to the first coil, the centers of the coils being coincident, then in general we find an electrodynamic force tending to turn the movable coil from one position to another. If the initial position of the coils is with their magnetic axes at right angles, then the passage of the current tends to displace the magnetic axes so as to make them coincident.

If a couple or torque is applied to the movable coil to bring it back to its original position, either by means of a spiral spring or a torsion wire, it can be shown that the couple required to hold the coils in their initial position, with magnetic axes at right angles to one another, is proportional to the mean value of the product of the instantaneous values of the two periodic currents passing through the two coils taken at equidistant intervals throughout one complete period. This mean product is, therefore, at once measured in terms of a mechanical couple. Such an arrangement is called an electro-dynamometer. If the current through one of these coils is the current being supplied to an inductive circuit, say a transformer, and if the current through the other circuit, say the movable circuit, can be made to be proportional to the potential difference between the extremities of the inductive circuit, then the dynamometer, now called a wattmeter, will give us when used as above described the true mean value of the product of the instantaneous values of the current through the inductive circuit and its terminal potential difference taken at equidistant intervals throughout the phase; this mean product is a measure of the mean power being taken up at that instant in the inductive circuit, and hence we are able by one measurement to measure this power.

In order that good results may be obtained with a wattmeter constructed as above described when employing alternating currents, there are certain precautions which must be observed but which instrument makers almost habitually disregard. In the first place, the wattmeter must be constructed entirely of non-conducting material. There must be no metal, either iron or brass, in or near the fixed or movable coils. The reason for this is that if metal is placed in this position, the alternating currents circulating in the fixed or movable coils set up eddy currents in this metal, and these eddy currents react upon the movable coil and cause a displacement which creates a false reading. In the next place, in order to make the instrument direct reading, it is essential that the fixed coil should be constructed in two parts, which are capable of being moved to or from one another, so as to strengthen or weaken the field in the place where the movable coil hangs. In this manner the wattmeter can be adjusted so that a certain angular deflection of the torsion head of the instrument, creating a certain definite couple acting on the movable coil, can be made to mean a certain definite amount of mean power passing through the instrument. Thirdly, pre-

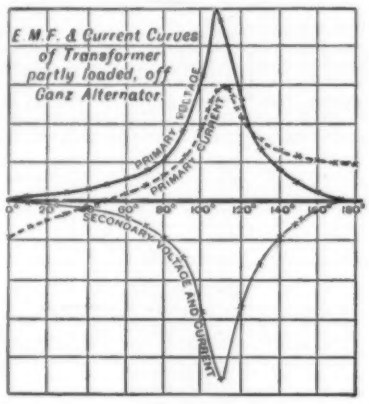


Fig. 34.

cautions must be taken to prevent the effect of the currents in the wires bringing the currents to or from the wattmeter affecting the movable coil.

For this purpose these leads ought to be constructed of concentric cable, and the wattmeter carefully tested before employment to find out if this cause of error exists. In the next place we require a non-inductive resistance to act as a standard power absorber. This can best be made by employing the cages as described in the first lecture. A series of these inductionless resistances, say 20 of them, each capable of withstanding a pressure of 100 volts, are joined up in series and well insulated. Under these circumstances a pressure of 2,000 volts can be placed on the extremities of this resistance and a certain current will flow through it. This current can be measured by a sensitive dynamometer, which has previously been calibrated in the usual way. The potential difference between the extremities of the non-inductive resistance when employed on a high tension circuit is best measured by means of an electrostatic voltmeter. Then lastly we require an auxiliary transformer for the following purpose. It has been explained in Lecture I that when a transformer of the closed iron circuit type is worked on a constant potential primary circuit, the secondary electromotive force set up in the secondary circuit is exactly opposite in phase to the primary electromotive force. This is further illustrated by the curves in Figs. 34, 35, 36 and 37, which show the primary and secondary

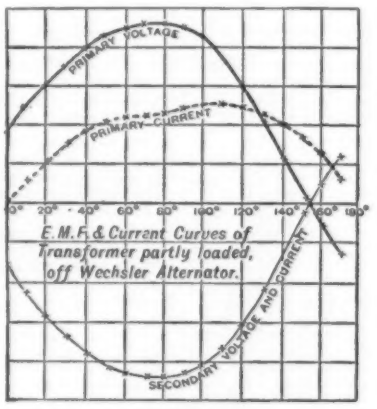


Fig. 35.

E. M. F. curves of a Ganz, a Wechsler and a Westinghouse transformer in various conditions of load, and it will be seen that the primary and secondary E. M. F. curves are in step with one another but opposite in phase. If, therefore, a transformer has its secondary circuit closed through a non-inductive resistance, the secondary current will always be exactly opposite in phase but proportional in magnitude to the potential difference between the primary terminals of the transformer.

In order, then, to make a measurement of the efficiency of any transformer, this apparatus is arranged as in Fig. 38, the transformer to be tested is denoted by the lines over the words "Transformer under test." The wattmeter has its fixed coils connected in series with the primary circuit of the transformer to be tested and its movable coil is connected in series with the secondary circuit of the transformer, which is called the auxiliary or wattmeter transformer, and by including a few incandescent lamps, L, in the secondary circuit of this auxiliary transformer, the proper current can be given to the movable coil of the wattmeter. The primary circuit of the auxiliary transformer is connected to the same two mains as the primary circuit of the transformer to be tested, and an electrostatic voltmeter, V, is joined across the primary terminals of the transformer to be tested. The standard inductionless resistance just described is also placed across the primary terminals of the transformer to be tested, and a two-way high tension switch is arranged so as to throw on the resistance or the primary circuit of the transformer under test at pleasure.

A dynamometer is connected in series with this standard resistance to measure the current passing through it. The process of measuring the power supplied to the transformer under test is then as follows: In the first place, we connect to the wattmeter the standard power of absorbing resistance, and observe the current flowing through it and the potential difference between its extremities. The product of these two numbers in amperes and volts gives us the mean power in watts taken up in the standard resistance. At the same instant a reading of the wattmeter is taken; that is to say, an observation of the amount of torsion required to be given to the wire or spring holding the movable coil to bring it back into its normal position. Let this reading be D_1, and let the power taken up in the standard resistance in watts be represented by W_1. In the next place, the standard resist-

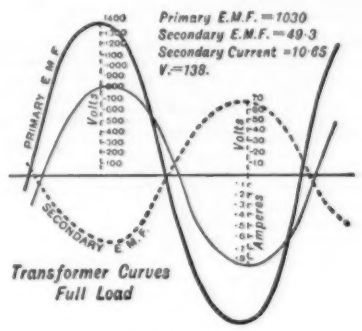


Fig. 36.

ance is switched off and the transformer under test is switched on to the wattmeter and another reading is taken of the wattmeter. Let this reading be D_2. The true power being taken up in this transformer under test is given by the value of the expression

$$\frac{D_2}{D_1} \times W_1.$$

In this manner the wattmeter is employed as a kind of electrical steelyard, to weigh or measure the ratio between the known power taken up in the standard resistance and the unknown power taken up in the transformer. A measurement can thus be made with extreme accuracy, either in a central station, a transformer substation or a private house. All that it is necessary to do is to connect the wattmeter, in the manner described, in place of one of the primary fuses; that is, to place the series coil of the wattmeter in series with the transformer under test and then to connect up the standard resistance and the auxiliary transformer, as shown in the diagram. The iron core loss of a transformer on open secondary circuit can thus be quickly and accurately measured, and, with a properly constructed wattmeter of the kind described, there is not the slightest difficulty in making the measurement of the core loss of any required degree of accuracy.

The wattmeter before you and the standard resistances have in this way been used for an extensive series of measurements on the efficiency and core losses of the transformers of the City of London Electric

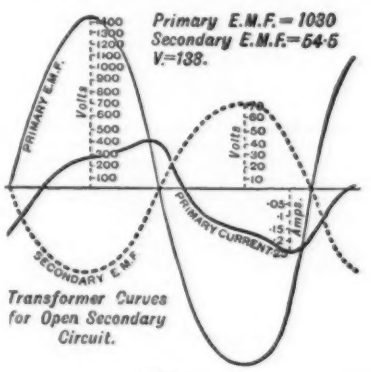


Fig. 37.

Lighting Company. No difficulty was found in making these measurements, even in the small underground substations which are distributed about the city. In addition to the iron core loss of the transformer on open secondary circuit it is also necessary to make two other measurements; one of these is the copper resistance of the two circuits of the transformer when the transformer is warm. The most easy method of doing this is by means of the fall of potential method. When the resistance of the primary circuit is moderately high, say anything over 5 ohms, it can be very easily measured on the ordinary post office Wheatstone bridge, taking the precaution, however, to short circuit the secondary circuit, but in those cases in which the resistance of either or both circuits is very low then it is best measured in the following manner. A suitable standard low resistance, either $\frac{1}{100}$ or $\frac{1}{10}$ of an ohm, or 1 ohm, is connected in series with the transformer circuit to be measured, and a small current from a dry cell or secondary battery is sent through this circuit, appropriate resistance being added to increase the total resistance to a proper amount. A movable coil high

* Lecture before the Society of Arts.—From the Journal of the Society.

resistance galvanometer has its terminals then connected first to the extremities of the standard low resistance and second to the terminals of the copper circuit of the transformer which is under test. The ratio of these two deflections gives us at once the ratio of the resistance of the transformer circuit to that of the standard low resistance, and in this manner the copper resistance of each circuit of the transformer can be measured. This copper resistance, however, if measured at the ordinary temperature of the air, has to be corrected to determine what it is when the transformer has reached its constant temperature. When a transformer is put to work, whether on open circuit or closed secondary circuit, it soon reaches a final temperature, which ought never, under any circumstances, to be more than 100° Centigrade.

In order to determine what this temperature is, one of the easiest methods is to connect the transformer on open secondary circuit for five or six hours to the high pressure circuits, and when the transformer has reached its final and constant temperature to suddenly switch

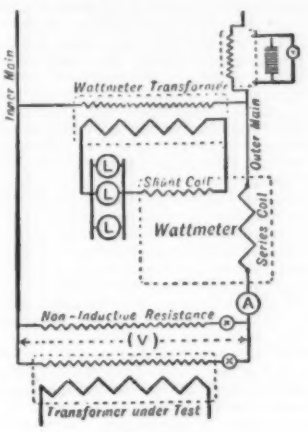


FIG. 38.

it off, and quickly make a measurement of the copper resistance of the secondary circuit as above described. Then, when the transformer is quite cold, another measurement of the copper resistance may be taken, which will be found to be much less, since the high conductivity copper employed in transformer manufacture has a temperature coefficient of about 0·4 per cent. per degree Centigrade. It is very easy to calculate from these two measurements what is the final and constant temperature of the transformer. Having then measured the copper resistances and calculated what it will be at the final temperature of the transformer, we have next to measure the secondary drop between full and no load. For this purpose an electrostatic voltmeter is connected across the secondary circuits, and its reading taken when the primary terminal potential difference is also known. The transformer is then loaded up to its full load on its secondary side, and the primary potential difference being kept at the same amount, the secondary potential difference will be found to have fallen, and the amount of difference between its value when the transformer is fully loaded and its value when the transformer is on open circuit is called the secondary drop. It is sometimes difficult to make this measurement with great accuracy, especially when the transformers are working off commercial circuits, but it can always be done in the way shown in the diagram in Fig. 39, if we possess two identical transformers and a low reading electrostatic voltmeter. The two transformers are connected up with their primary circuits in parallel, and with their secondary circuits opposed to one another through the voltmeter. The voltmeter then reads, not secondary volts to either transformer, but the difference between the two differences.

If one transformer is loaded up to full load, the volt-

Diagram of Connections for measuring the Drop in Volts of a Transformer.

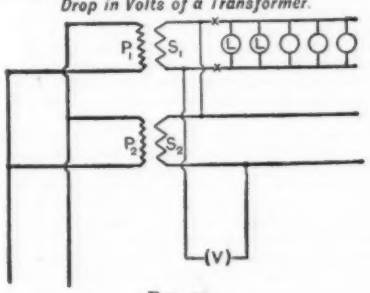


FIG. 39.

meter will read directly the secondary drop, and since both transformers are affected equally by any variation of the primary pressure, it does not affect their difference, and, therefore, there is no difficulty in getting the measurement with any required degree of accuracy. Having in this manner measured the iron core loss at no load, or on open secondary circuit, the copper resistance when the transformer is warm, and the secondary drop, we have all the information necessary to enable us to make a complete report on the transformer. It has been abundantly shown by experiments which were carried out by me in the year 1892,* that when a transformer is gradually loaded up, the iron core loss is constant at all loads, and that it is only the copper losses that vary.

Hence, if we know the iron core loss, that is to say, the loss due to eddy currents and hysteresis in the core when the transformer is on open secondary circuit, we have only to add to this loss the copper losses in the transformer, that is, energy losses due to the resistance of the copper circuits, in order to obtain the total power absorption in the transformer at any load. Let P_1 be the total power in watts given in a transformer on the primary circuit, and let P_2 be the total power in watts given out on the secondary circuit to some external resistances, such as lamps. Let I be the total iron losses in the transformer and C the total copper losses. $P_1 = I + C + P_2$. Hence the difference between P_1 and P_2 is a quantity which can be calculated when we know I and C; and the efficiency of the transformer is given by the ratio of P_2 to P_1, expressed as a percentage.

The copper losses can be calculated with sufficient accuracy in the following manner: Let us suppose that the transformer under test is a 10 kilowatt transformer, that is to say, is constructed to permit 10,000 watts being taken out from the secondary circuit, and that the secondary watts are intended to be 100. Then the transformer at full load will give out a current of 100 amperes. If we imagine the full load of the transformer to be divided into 10 parts, then when the secondary circuit is delivering 10 amperes at 100 volts the transformer is on 1-10 load, when it is delivering 20 amperes at 100 volts the transformer is on 2-10 of full load, and so on. If the transformation ratio of the

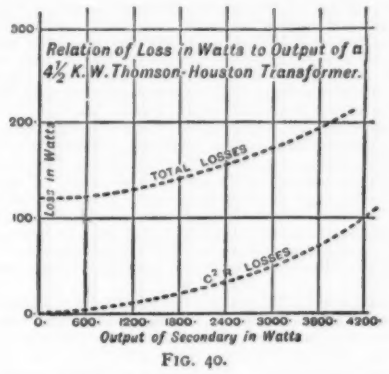


FIG. 40.

transformer is known, that is the ratio between the secondary volts and the primary volts, or secondary terminal potential difference and primary terminal potential difference, when the transformer is on open secondary circuit, then the primary current can always be calculated with approximate accuracy from the secondary current by simply multiplying the secondary current by the number expressing the transformation ratio.

Hence we can calculate the primary and secondary currents corresponding to each decimal fraction of full secondary load. Knowing the resistances of the two circuits of the transformer when warm, we can, therefore, calculate the copper losses in each circuit, because if R is the resistance of a circuit, and C the R. M. S. value of the current flowing through it, then $C^2 R$ is equal to the mean power wasted in that circuit. Calculating in this way the total copper losses for the two circuits corresponding to each decimal fraction of the full secondary load, we can add these values to the constant iron core loss experimentally determined, and obtain the total power lost in the transformer, corresponding to each decimal fraction of full load. We have, therefore, the difference between P_1 and P_2, corresponding to known values of P_2. Hence we can calculate the ratio of P_1 to P_2 for each decimal fraction of the full secondary load, and therefore we have the efficiency of the transformer, and the total loss in the transformer given to us at each fraction of the full secondary load. This is by far the best method of determining the efficiency of very large transformers, because it does not necessitate loading up the transformer to its full load on an actual resistance; and even if this can be done,

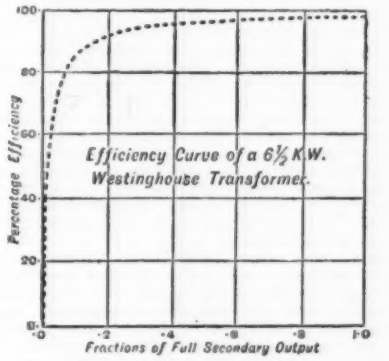


FIG. 41.

the measurement which we actually require is the difference between two large observed quantities, and is, therefore, very liable to be affected by an error in either of them. Having obtained in this manner the total losses in the transformer for the various decimal fractions of the full secondary load, the most convenient graphic method of representing the results is by a total loss diagram.

A horizontal line is taken, and is divided into 10 equal parts representing the decimal fractions of the full secondary load. At each part a vertical line is set up, representing the total losses in the transformer, both the copper and the iron losses, and two curves are drawn, as in Fig. 40, one representing the variation of the total copper losses in the transformer with the secondary load and the other representing the constant iron loss at all loads. From this curve another curve, called the efficiency curve, can be drawn in the following manner (see Fig. 41). A horizontal line is taken, representing the secondary output, and divided into 10 equal parts representing the decimal fractions of the full secondary load. At each point a vertical line is set up, representing the ratio between the power given out by the transformer to the power taken in by the transformer, expressed as a percentage, and the curve delineated by these points gives us the efficiency curve of the transformer. In a well designed transformer this efficiency curve is a square shouldered curve, rising very rapidly up to 90 per cent. at one-tenth of full load, and to 96 or 97 per cent. at full load. A fairly good estimate of the value of a transformer from an efficiency point of view can be obtained by taking its efficiency at one-tenth of full secondary load. Even quite small transformers are now made which have an efficiency of 80 per cent. at one-tenth of full load. Large transformers of 30 to 50 kilowatts and upward can be made to have an efficiency of 90 per cent. at one-tenth of full load. Ten years ago it was difficult to get any transformer having more than 40 to 50 per cent. of efficiency at one-tenth of full load.

It should be noted, however, that the form of this efficiency curve, as well as that of the current curve, depends upon the nature of the curve of primary E. M.F. The diagram in Fig. 30, Lecture II, shows the difference which may exist in the efficiency curves in the case of the same transformer tested in two different alternators, a Ganz and a Wechsler.

(To be continued.)

* See "Experimental Researches on Alternate Current Transformers," by J. A. Fleming. "Proceedings of the Institution of Electrical Engineers," November, 1892.

FISH NETS.

SOME ACCOUNT OF THEIR CONSTRUCTION AND THE APPLICATION OF THE VARIOUS FORMS IN AMERICAN FISHERIES.

By C. H. AUGUR.

WE know of ten distinct devices for the capture of free-swimming fish—the spear, the snare, the hook, the dip net, the seine, the pound, the cast net, the gill net, the trammel net, the beam trawl. We think that any appliance called by any other name whatever will be found to embody the basic principle of one of these ten.

When, and in what order, and by what kind of fishermen these various methods were first conceived and brought into use, we do not know. If we should trace their development from the beginning, we must draw upon our imagination, for they are old devices; so old that history affords but little information as to their first conception. We know that certain birds and animals are expert fish catchers, and we may imagine that the first fisherman imitated the salmon-catching bear, taking his piscatorial food from the water without other implements than those provided by nature in his strong arms and nimble fingers.

But it is an accepted fact that no fisherman was ever quite satisfied with his achievements, and we may assume that the primitive fish catcher soon began to look with covetous eye on the gamier fish; that he was sorely exasperated to see the finest specimens elude his grasp and swim with tantalizing dignity into the depths beyond his reach. Possibly it was one of these earliest fishermen who originally told how "the biggest fish got away," and it may have been the significant exchange of glances among the aboriginal cronies which fired him with a determination to capture that biggest fish by fair means or foul in order to maintain his reputation for veracity.

What sort of an implement would be devised under such circumstances? Probably a spear, and it is not unlikely that for a long period of time after the introduction of this device our pioneer fishermen were to be seen furtively stealing about the banks of streams and the shores of the sea and lakes, practicing the "gentle art" by jabbing these cruel instruments into the flesh of their victims, or, when not thus engaged, devising improvements in the shape, style and quality of their tackle—employing their time very much as fishermen do in the nineteenth century.

The snare has been referred to, not because it is now of any importance, but because it is a means of taking fish different from any other. It is one of the crude devices which would naturally suggest itself to a man without implements of any kind, who should see fine old fish lying between the rocks just beyond his reach. The nearest sapling would supply him with a pole, some twisted grass or bark fiber with cord to form a loop, careful adjustment of this to the tapering end of the pole, a little cautious manipulation of the tackle, the loop encircles the fish, is tightened by a sudden pull, and the victim landed flopping on the bank. We know from personal experience that nature has produced fish stupid enough to be taken in that manner.

Along with spear and the snare, some sort of a hook may have been devised, but we imagine that it was in the form of a gaff, and that the fishing industry was in a more advanced condition before the fishhook, as we now know it, came into use.

The habit of many slow-moving fishes to rest lazily on the gravelly beds of shallow rivers, and of others to congregate at the headwaters of streams in spawning season, and of still others to take temporary shelter in quiet nooks behind the rocks while ascending rapids, must have suggested the use of the dip net—first made, we may suppose, of woven grass, attached to a bent sapling, afterward of leathern thongs or some stout vegetable fiber twisted into cord of suitable size and knotted into meshes.

All these methods contemplated the capture of such fish as might be found in shallow water and in plain sight of the fisherman. Then we imagine arose the genius who first conceived the idea of luring the fish out of the safe places and inviting him to destruction by the offer of tempting food. We may suppose that bait was first used to attract the fish within the range of the spear, and that afterward, as the result of another inspiration, it was attached to a hook which the victim might take into his mouth. This was a tremendous advance in the development of fishing methods. Surely the catches increased enormously and intelligence of the new device must have spread rapidly among the tribes. We may confidently believe that at this time some of the old men, seeing the jubilant and heavily laden fishermen returning day after day from the fishing grounds, originated the remark which has been handed down through the ages and which, in its simplest form, runs about like this: "If this thing keeps on, the good fish will be caught out of the water in about three years." Yet notwithstanding the dire predictions of disaster, there was probably no appreciable diminution in the supply of fish, and the ingenuity of the fishermen continued to exercise itself in de-

vising ways and means to still further augment the catch. It occurred to some one to apply the lure, or bait, in combination with the dip net; that is, to set a baited net of similar shape in the water resting on the bottom, to be suddenly raised when a number of fish had collected above the netting and were busily dissecting the food.

The time came when the possibility of capturing by one operation a large number of those fish which periodically visit the coasts and rivers in immense schools attracted the studious attention of the ambitious fisherman. These fish would not go to the bottom to feed on bait deposited in his dip net. Then, instead of spreading the net beneath them, why not throw it over them? This clever idea resulted in the device known as the cast net, which, from all the references to fishing nets in ancient writings, we believe to have been one of the earliest devices used by those to whom fishing was a means of livelihood. Yet it is not by any means one of the simplest devices, for the successful application of it requires great skill.

Another fisherman who seems to have lived before people began to record important events devised the sweep seine. This form of apparatus may have been adopted either as a means of stopping and encircling large numbers of school fish passing along the coast, or as a method of capturing such fish as might be feeding upon the grounds easily swept or dragged by a net of its character.

It was perhaps observed by some of the earlier seine fishermen that the immense schools of fish journeying along the coasts at certain times and seasons were often below the surface and invisible, and that they were intermittent, passing at unexpected hours, when the fishermen were telling yarns or were asleep in their bunks; and from this observation the idea of the appliance which is known as the pound, or weir, may have originated. There is a belief current among our fishermen that the pound is of recent origin, but it is said that the American Indian used such a device, constructed of poles and brush, before the advent of the white man, and if that is true, who can tell for how long a period this apparatus may have been employed? The belief that an aperture could be made opening into the pound which would not also be freely used by the fish as a means of exit, must have been founded upon a considerable knowledge of the nature of fish, and surely it was one of the distinctly original ideas in the history of fishing methods. It has been utilized in the construction of innumerable minor nets, among which are included a great variety of fykes and pots, although in the pot the idea of the funnel is applied in combination with the lure, and not with the leader; that is, the fish are attracted to it by the bait, not driven in by obstructions to their natural progress.

In the net we have referred to are found pretty effectual means for the capture of all fish which swim near to the land, either in the sea or in the rivers. For those which inhabit waters of great depth the gill net, quite distinct from all other nets, was devised and brought into extensive use. In this net the fish is not surrounded and dragged to shore, nor lured by the use of bait, nor drawn from his course and led into captivity; he is required merely to run his head blindly into the meshes, which are composed of the finest twine or thread it is practicable to use, in order that they may be as nearly as possible invisible.

A method differing from all others referred to is found in the use of the trammel net. Like the gill net, the trammel may be stationary or allowed to drift with the current, but, unlike the gill net, it is so constructed as to catch fish varying in size.

The shore fisheries thus being provided with most effective apparatus, and the gill net devised for the high-swimming ocean fish, there still remained for the attention of the net fishermen those fish which inhabit deep waters, but do not rise far above the bottom. The beam trawl met this particular long-felt want. It is, however, an apparatus more familiar to the fishermen of Europe than us. There the beam trawl fisheries equal in importance those of any other method, while here such experiments as have been made with them have proved unprofitable, and their use in the commercial fisheries is so limited as to hardly warrant consideration.

Now, if our attempt to account for the introduction of the various forms of fishing apparatus seems too fanciful, and does not accord with established facts, we are anxious to be enlightened by any one who knows better. The interesting fact is that all of the distinctive methods known at this time are of ancient origin: and it is a fact less scarcely noteworthy that every one of the appliances referred to, except the shore (and perhaps we should apologize for mentioning this device at all), is employed to some extent in the commercial fisheries of the United States even to this day.

The principle of the spear is applied in the whale and the swordfish fisheries. The spear in its simplest form is a common device successfully employed in fresh water lakes in winter fishing through the ice, and in taking eels from the muddy beds of the shallow creeks and harbors along the seacoast.

The dip net in its original form yields profit to the Indian fishermen in certain salmon rivers on the Pacific coast. The finest whitefish served at the hotels in Sault Ste. Marie are taken by the same primitive device by the native Indian fishermen, whose birch canoes may be seen at almost any time far out in the foaming rapids, manned by two men, one poling the canoe steadily up the stream, the other standing in the bow, dexterously scooping the fish from the quiet pools behind the bowlders and rocks.

In South Carolina also this form of net is used to capture shad in very much the same way as the Pacific coast fishermen take the salmon; that is, by continually plunging the net at random into the swift-running current, from a position on the bank of the stream in such a way that one or more of the large numbers of fish passing upward to the spawning grounds may run into it.

The Columbia River salmon wheel is an application of the dip net principle, and the dip net used in combination with bait you may find in all parts of the country. Scores of them are in operation all summer long from docks about Chicago, supplying anglers with fine strings of perch for exhibition purposes at reasonable prices. The hook we all know is more extensively employed than any other device in the commercial fisheries, notably in the cod fisheries. The cast net is found in common use along the Southern coast, more especially in Florida and the Gulf States. Seines, pounds and gill nets are three forms of apparatus of paramount importance to American fisheries.

The trammel net is used chiefly in the great rivers flowing into the Gulf of Mexico. It forms one of the most important means of capture in the market fisheries of the Mississippi. The fyke is used in the same section of the country, perhaps more extensively than in any other part, but this net is to be found on all seacoasts and in the lakes and rivers.

The beam trawl, as we have intimated, has not been employed profitably here, but its use is known, and the same principle is applied in the oyster dredge. It is not our purpose, however, to discuss the methods employed in the shellfish fisheries.

Having referred generally to the various kinds of nets used in American waters, and supposing that all here present are familiar with the principles employed in their construction, it may nevertheless be proper to describe those which are of most importance. Seining has been applied in America, as we believe it has nowhere else, to the offshore deep-sea fisheries, by means of contrivances for pursing the net. In the mackerel, menhaden and salmon fisheries the purse seine is most extensively used.

The menhaden purse seine is from 150 to 200 fathoms in length and from 50 to 75 in depth. It is hung to double lines at the top and bottom, one right and the other left laid. The top line is fitted with corks sufficient in number to sustain the weight of the seine and float at the surface. At intervals along the bottom of the net iron or brass rings about three and a half inches in diameter and a little less than a pound in weight are attached to the hanging line. The purse line—Russia bolt rope, one and three-quarters inches in circumference—is passed through these rings. Two seine boats are used in operating the net, half of which is stowed in each boat. The boats are towed behind a fishing steamer, while cruising about in the waters where menhaden are known to be, until a school of fish is sighted at the surface, when they are manned and put off.

Having reached a proper position near the school of fish, the boats are rowed around it in a circle, starting in opposite directions, the seine being paid out as they proceed. When the fish are surrounded the crew of one boat enters the other, and all hands proceed to purse the seine—that is, to close the circle formed by the lower edge of the net by means of the purse lines and rings, as the mouth of a bag would be closed by a puckering string. The pursing is accomplished with the aid of a heavy, beet-shaped leaden weight dropped over the side of the boat, and having two blocks attached on opposite sides, through which runs the pursing line to the boat davits above. But it is quite impossible to describe this operation intelligibly without the aid of a sketch or model. When the seine has been pursed it is hauled aboard the boats until the fish are gathered into the bunt, when the steamer comes alongside and the fish are taken aboard by means of a bucket and derrick rigged on deck for the purpose.

This illustrates the principle of the purse seine. The difference in methods of application in the other fisheries is chiefly confined to the boats and vessels employed. A seine fashioned on this principle is said to have been operated off the coast of Rhode Island as early as the year 1826. It was a small net, and apparently was not a marked success, as nothing more seems to have been heard of purse seines until about 1860, since which time they have been in general use.

The pound, introduced into the commercial fisheries in Connecticut about the year 1850, and soon afterward adopted by the New England fishermen, has come to be very generally employed. On the Great Lakes it is found in the form which is perhaps most effective where the use of a tunnel is practicable. The leader of the lake pound is from fifty to seventy-five rods in length, the two heart webs each nine rods in length, the pot thirty feet square, and the tunnel running from the end of the heart into the pot is of a length proportioned to the depth of water. The tunnel at the mouth is thirty feet wide, and of the same depth as the hearts, tapering to about three feet square at the small end, which extends eight or ten feet into the pot. The netting is hung in Manila rope one-half inch in diameter. All the parts are held in position by poles driven into the bottom of the lake. The nets are set in the water varying from fifteen to seventy-five feet deep, and in a few cases they have been made to set from ninety to a hundred feet deep. The upper lines of the leader and heart are even with the surface of the water. The pot extends three or four feet above the surface. In some minor particulars, such as the size of the lines, the opening in the tunnel, etc., the construction of the nets in some fisheries may differ slightly from the description we have given.

In the ocean pound, which has to contend with stronger currents and with floating seaweeds, the tunnel does not seem to be practicable. In its stead a second small heart is sometimes constructed, the converging point extending into the pot, leaving an opening from two to ten feet wide between the poles.

In the weir, extensively used along the coast of the Eastern States, we have the same principle differently applied—round pots or bowls take the place of the ordinary square pot and the net being held in position by poles, together with an elaborate system of guy ropes and anchors.

It is not practicable to give here more than these general particulars regarding the pound. The details of its construction vary in a hundred ways, according to the nature of the fishing grounds and the ideas and whims of the fishermen.

Gill nets are employed in the fisheries in great variety. In the large rivers flowing to the ocean gill nets are used for the capture of those fish which ascend to the headwaters in the spawning season. These river drift nets are employed chiefly for the capture of shad and salmon, and the methods of operation in taking the two kinds of fish are much alike. The nets fitted with corks, buoys and bottom weights are stretched across the river and allowed to drift with the current, following one another at frequent intervals. Drifting or floating gill nets have been used from the earliest times in the ocean fisheries for the capture of mackerel and herring.

Gill net fishing on the great lakes is a very different operation. Here the nets are only four feet in depth. They are hung to light cotton lines, heavily weighted with cedar floats to keep them in an upright position, and sunk to the bottom in water of any depth varying from ten to seventy-five fathoms. In the larger fisheries they are operated from steam fishing boats, each boat having an outfit of nets which, if fastened together and all set at one time, would stretch to a continuous length of from twenty to thirty miles. Gill nets of different proportions, but operated in a similar way, are employed in the cod fisheries of the seacoast States.

The mullet and shad gill net fisheries of the Southern States have in recent years become very important, and from Florida to Maine the gill net is used to some extent for nearly all varieties of high-swimming marketable fish.

In the first half of this century the American fisheries, so far as they were carried on by the use of nets, were limited in extent. Gill nets and sweep seines were the principal means of capture employed, and were operated along the Atlantic coast extensively enough to supply the local markets with fishery products, but, except in the New England States, they were not of great importance. During the latter half of the century the development of net fisheries, encouraged by the growth and spread of population, with the consequent extension of markets and by the perfection of transportation facilities, has been marvelously rapid. Gill nets stretch their interminable lengths throughout all the waters inhabited by edible fish—in the oceans east and west, in the rivers flowing into them, and in the great fresh water lakes. Sweep seines, although for the most part abandoned in the great New England fisheries, find profitable employment in other localities, where they are better adapted to the fishing grounds. They are found in large numbers of great size on the Pacific coast. They form practically the only means of capture in the important net fisheries of the Gulf of Mexico. The capacity of the modern sweep seine is greater than the earlier fishermen would have believed possible. In the bays of North Carolina the seine sweeps several miles of fishing ground at one operation, being paid out of the deck of the steamboat and hauled by steam power stationed on the land. The purse seine steamers cruise about in the inexhaustible field afforded by the deep waters of the ocean. Wherever you may view a great expanse of water the black poles of the pounds, traps and weirs attest the universal presence of these appliances. In its special field of operations the trammel net is numerously employed. Fykes, pots, small seines and traps of multifarious form abound everywhere.

If it is true that during this period of remarkable expansion of the commercial fisheries no entirely new principle has been introduced in methods of capture, it is also true that the elaboration and application of old methods have been sufficiently progressive, and the observation of these changes is within the special province of the net and twine manufacturer, who views the whole field of operations and who is compelled to adapt his business to every new condition. Fishermen now living recall the time when half a dozen sizes of hemp twine of a rather ordinary quality sufficed for the requirements of all the American fisheries. In the year 1893 there were between eighty and ninety different kinds and sizes of twine in constant use as material for netting, and the variety is increased to more than a hundred kinds and sizes if we include such as are used for gill net hanging lines.

Previous to 1840 it had not occurred to any one apparently to supply the fishermen with ready made nets. In the twelve months of the present year the netting manufacturer, whose business extends through all the fishing districts, will have been called upon to supply more than three hundred distinct varieties of netting; that is, as many kinds as can be made up by the use of every conceivable size of mesh, duplicated in from two to thirty different sizes of twine. More than thirty sizes of mesh and forty kinds of twine are required for the gill net fisheries alone, the meshes varying from one and three-quarters inches (extended measurement) to thirteen inches, and the twines from the size of a single horsehair to thirty-six thread cotton, which is nearly one-eighth inch in diameter. Of the great variety in sizes and twines referred to, all but a few are made of cotton, no hemp twine being used in our fisheries, and linen only where the yarn must be spun to extreme fineness, as in the gill net fisheries of the Great Lakes.

The substitution of cotton for hemp twines in the American fisheries was a matter of considerable importance, for its results were far reaching, affecting the great fisheries of European countries hardly less than those of our own. The incident which led to this important step is here related:

Some time in the year 1844 a fisherman, known to history as Mr. McCarthy, whiling away an hour in a small store in Boston, where he bought his fishery supplies, expressed an opinion that somebody in this country might turn an honest penny by getting up a twine especially designed for nets and better adapted to the purpose than the imported hemp twine then used. This proposition was discussed in the presence of Mr. James S. Shepard, who was then engaged in the manufacture of cotton yarns at Canton, Mass., and he very soon afterward submitted to Mr. McCarthy, the fisherman, a cotton twine, which the latter made into gill nets and submitted in turn to the herring family of fishes for a final verdict. It was pronounced a satisfactory twine by Mr. McCarthy and was at once adopted by the fishermen, but candor compels us to say that the fishermen of the present day would not accept it as a gift. The best that can be said of it is that it was an improvement upon the hemp twine.

Soon afterward the popularity of cotton twines for both gill net and seine fishing induced Mr. Shepard to devote his whole time to their manufacture and improvement. The product of his factory was taken by the proprietors of the store we have alluded to, who for some years had been supplying fishermen in a small way with nets made by hand knitters in and around Boston. This concern was the nucleus of the present American Net and Twine Company, and included Mr. Shepard in its membership a few years after the events narrated.

Aside from the introduction of the new twines, methods of manufacture did not undergo any considerable change for some years; seines and gill nets continued to be the chief form of apparatus, and the netting was made by hand, women and girls being em-

ployed to do the work. The variety and sizes of the twine and mesh were very small. The fishing industry was attaining considerable proportions, however, and the use of cotton twines stimulated a demand for them which induced other yarn manufacturers to engage in their production.

In the year 1858 the net and twine company referred to imported the first netting machine used in the country. It was a hand power Scotch machine, the only kind then in existence. The Scotch machine was not, and we believe it never has been, adapted to the manufacture of heavy netting, so that after its importation all netting, except that composed of fine twines, continued to be made by hand. For light netting, however, the company built in their own factory several machines of the Scotch pattern.

The limitations of this netting machine led the Net and Twine Company to expend a considerable sum of their money in attempting to develop two or three inventions designed to overcome the difficulty of knitting heavy twines, but none of them proved satisfactory. In 1862 a newly invented machine, quite different in principle and well adapted to heavy work, was put in operation. Some years afterward an ingenious native of the State of Connecticut, Mr. Squire, invented a machine for knitting fine threads which possesses many advantages over the Scotch machine.

The larger netting companies are using the Scotch machine, which has been improved somewhat in construction, and the one hundred and sixty-two power machine, and the company we have spoken of use also the machine of American invention in the manufacture of fine thread netting. They have purchased the rights of the inventor.

The extensive introduction of these different machines was, of course, a process of gradual accomplishment, and while it was taking place the fisheries were undergoing that wonderful expansion which we have little more than indicated in this paper. Without the machines it would not be possible to produce the great variety of twine and netting used, and it is true, no doubt, that the ability of the netting factories to supply everything imaginable has induced the fishermen to adopt a great many sizes of mesh and twine which would not otherwise be considered necessary.—The Fishing Gazette.

GOLD EXTRACTION PROCESSES.

By T. K. ROSE, in Science Progress.

FROM very early times the ancients were attracted by the beautiful color, the brilliant luster and the indestructibility of gold, and spared no pains in the endeavor to acquire it. In the code of Menes, who reigned in Egypt some 2,000 years before the time of Moses, the ratio of value between gold and silver is mentioned, one part of gold being declared equal in value to two and a half parts of silver, and it is, therefore, clear that the extraction of both metals from the deposits containing them must have been carried on before that time. It is indeed probable that gold was the first metal observed and collected, since it occurs in fragments of all sizes in loose sand, and the operations of collecting the larger pieces and melting them together are so simple. Among the rock carvings of Upper Egypt there are several illustrative of the art of washing auriferous sands by stirring and working them up by the hand in hollowed-out stone basins, and subsequently melting the gold in simple furnaces with the aid of mouth blowpipes. The earliest of these carvings is supposed to date back to about 2,500 B. C. However, in ancient times, gold appears to have been mainly derived from India, and that country continued to supply most of the gold used in Europe until the discovery of America by Columbus.

In order to collect alluvial gold, the sands were washed down over smooth sloping rocks by means of running water, and the particles of gold, sinking to the bottom of the stream by reason of their high density, were entangled and caught by the hair on raw hides spread on the rocks. Among the hides used were sheepskins, and hence originated the form of the legend of the Golden Fleece. Stripped of its heroic dress this legend of course described a piratical expedition to win gold which was being obtained from streams with the help of sheepskins by the inhabitants of what is now Armenia. Similar expeditions have not been unknown in much later times, and the method of obtaining gold by washing river sands is still practiced with improvements in matters of detail in many parts of the world. Hides are even now occasionally employed to catch the gold, but sheep's wool when used is generally in the form of blankets.

The use of mercury as an aid in the collection of gold contained in river sands or in crushed rock is also of great antiquity. The earliest mention of quicksilver itself appears to occur in the works of Theophrastus, about B. C. 300; but Diodorus of Sicily, who saw gold being extracted from quartz in Upper Egypt in the time of Julius Cæsar, does not refer to its use.* Only a few years later, however, Vitruvius,† about B. C. 13, described the manner in which, by the help of quicksilver, gold was recovered from cloth in which it had been interwoven, and in Pliny's time the separation of gold from its impurities generally by the same means was well known.‡ It is probable that this knowledge was never afterward entirely lost, although the references to it in the middle ages are very scanty. For example, Geber§ in the eighth century was aware that mercury would dissolve considerable quantities of gold and silver, but not earthy materials, and Theophilus the monk,‖ in the eleventh century, carefully described the method of washing the sands of the Rhine on wooden tables, the final operation consisting in treating the concentrates with quicksilver for the removal of the gold. Biringuccio ¶ was taught the secret of this use of mercury in Italy some time before 1540 in return for the present of a valuable diamond ring, and it is clear that the so-called invention of the amalgamation process in Mexico by the Spaniards in 1557 was only the introduction or adaptation of a process already well known in Europe.

The existing methods of washing auriferous sands all depend on two principles—the great density of gold when compared with that of the siliceous material with which it is associated and, as Baron Born expressed it over 100 years ago, the "elective affinity" of mercury for gold when mixed with impurities. The ease with which gold amalgam can be collected in spite of its being less dense than gold is of course due to the fact that it is miscible in all proportions with mercury, so that under proper conditions large globules of liquid alloy are formed by the running together of smaller particles, and the former are readily caught in suitable crevices.

A large number of implements of varied form and efficiency are used in different parts of the world to apply these principles. In operations on a small scale the batea, the trough and the miner's pan are chiefly used. In South America, in West Africa, and in parts of China, the batea is used, a wooden vessel having the shape of a very short reversed cone. When held in the hands and filled with gravel and water, a peculiar gyratory motion imparted to it results in the collection of the gold in the apex of the cone, and the light material can then be readily washed away.

A small wooden trough, twelve or fifteen inches long, is used for the same purpose in the far East by the Chinese, the Tonquins, the Annamites, the Malays and others, the water being made to flow up and down until the gold has settled to the bottom. The miner's pan, a flat-bottomed iron vessel with sloping sides, was first used by the California pioneers, but has now become the favorite implement of Europeans for prospecting in all parts of the world. In early days in Australia and California millions of ounces of gold were obtained from the river gravels by its use, but apart from its value in prospecting, it is at most a rough and ready means of treating small quantities of rich material, and is only suitable to individual effort.

In combined efforts to treat larger quantities of sand, the machines all consist essentially of a slightly inclined trough, through which a stream of water is made to convey the auriferous sand, mercury being usually sprinkled on at short intervals of time. If the trough is long enough, and the stream of water not too rapid, the gold and mercury sink, and, uniting, are swept along together, until arrested by some inequality of the bottom.

Crevices and "riffles" or obstructions of various kinds are arranged to catch the amalgam. The simplest contrivances are transverse slats of wood nailed to the bottom of the trough or sluice. In Siberia square "pigeonhole" depressions have been continuously used for more than fifty years. In California, the sluice is paved with square blocks of wood placed an inch or more apart, or with large rounded stones, or ordinary iron rails between which are plenty of crevices where the amalgam can lodge. To catch light spangles of gold, blankets are spread, the loose fibers of which become charged with pyrites and gold, and in New Zealand plush is a favorite gold catcher.

When a "clean up" is desired, a stream of clear water is run through the sluice, the riffles are taken up, the mercury and amalgam washed down and allowed to accumulate at some convenient spot, and then ladled out and squeezed in bags of canvas or leather as in the days of Pliny, who describes the process as follows: "Ut et ipsum [i. e., argentum vivum] ab auro discedat, in pellis subactas effunditur, per quas sudoris vice defluens purum relinquit aurum." The excess of mercury being thus filtered off, the pasty amalgam, containing about one-third of gold, is retorted.

The methods of conveying the auriferous material to the sluices vary with the scale of the operations and the other conditions. When rocking cradles or the smaller sluices are used, the gravel is shoveled into them. In Siberia, where the valleys are shallow and the inclination of the ground small, the gravel is carried in carts up an inclined plane to an elevated wooden platform whence the sluice starts. In California, where the gulches are deep, the fall of the ground rapid, and the auriferous deposits of great thickness, the banks of gravel are attacked by jets of water of tremendous power, and the earth washed down and carried through the sluices without being touched by hand, the so-called "hydraulic method." When the gravel beds are below the general level of the country they are raised by the "hydraulic elevator," a jet of water, under a head of as much as 400 or 500 feet, carrying water, sand, and bowlders alike up a pipe inclined at some 60 degrees to the horizon, so as to deliver them all at the head of the sluice, the vertical lift being sometimes over 40 feet.

One of the main difficulties in the hydraulic process is in the disposal of the tailings, which are usually discharged into a river or into the sea. The enormous amount of loose sand and gravel delivered from the hydraulic mines into the Yuba and Feather rivers, California, prior to 1880, filled up their beds to such an extent that in rainy weather disastrous floods ensued, and much valuable agricultural land was buried beneath sterile drift deposits and rendered worthless. The farmers thereupon took action against the mining companies and obtained a perpetual injunction forbidding the discharge of tailings into these rivers. The result has been to stop the use of the hydraulic method in these important districts, and an apparently irreparable blow was inflicted on gold-winning industry in California.

In every country as soon as the richest of the placer beds have been worked out, efforts are made to extract the gold from quartz veins. The quartz must of course be crushed, and the crushed material has in the past been generally treated similarly to the auriferous sands occurring naturally. Thus, according to the account given by Diodorus Siculus, already referred to, the quartz was reduced to coarse powder by pounding it in stone mortars, then finely ground in handmills resembling the flour mills of the present day, and finally washed down over inclined planks with water, when the lighter material was carried away and the heavy gold retained on the wood. Hollowed out stone mortars suitable for the first of these operations have been found in many parts of the world, including Wales, Central America, the Pyrenees, and Transylvania. The stamp mill has no doubt been evolved from the pestle and mortar, but was not used for crushing ores until about the year 1519, when the process of wet stamping and sifting was introduced by Paul Grommestetter, in Joachimsthal, the two operations, however, being at first kept distinct.

Agricola has given an exact description of the treatment of auriferous quartz in Germany in 1556,* from which it appears that the methods in use at that time were strikingly similar to those still employed in Transylvania and the Tyrol, which were among the districts of which he wrote. Doubtless in these districts the methods have been handed down from generation to generation with little change, while in other countries where they were introduced hundreds of years later the changes have been rapid and striking. In those points in which the older Tyrolean practice differed from the modern one it resembled the procedure of the old Egyptians. The wooden stamps, shod with hard stone or iron, were arranged in sets of three, and raised by cams to fall by gravity when released. The rock was shoveled dry into the mortar, and coarsely crushed by the blows of the stamps.

Next it was ground as fine as flour in a stone mill supplied with water, and carried by the stream of water into the uppermost of three wooden tubs, whence it overflowed in succession into the other two. Revolving mechanical stirrers furnished with six paddles kept in agitation the contents of the tubs, and "separate even very minute flakes of gold from the crushed ore. These flakes, settling to the bottom, are drawn to itself and cleansed by the quicksilver (lying in the tubs), but the water carries off the dross."† Agricola here expounds the theory of amalgamation still adhered to in Austria, where mercury is regarded merely as a useful means of collecting particles of gold which have already been separated from the crushed ore by their great density. The Tyrolean bowls still in use at Vorospatack in Hungary and in a few retired valleys in the Eastern Alps do not differ essentially from the tubs drawn and described by Agricola; and, although wet crushing by the stamps has been introduced, the mortar is not usually furnished with screens.

Elsewhere, the changes in stamp battery amalgamation since Agricola wrote his treatise have been many and great. One of the first was the addition of screens in the side of the mortar, so that the two operations of crushing and sifting were united. In 1767 M. Jars saw these in use in the Hartz,‡ though even then only a single screen of brass wire twelve inches square delivered the product of three stamps, and in several other districts of Germany screens had not been adopted. The most important improvement however has undoubtedly been the introduction of the amalgamated copper plate for catching gold, the complement of the practice of charging mercury with the ore into the battery and so combining the operations of crushing and amalgamation. No mention of either this practice or the use of copper plates appears to have been made before stamp batteries began to work in California in 1850, although they had very likely been used in Georgia for some time previously.

The use of the copper plate was probably suggested by the experience in Mexico and South America of the working of the Cazo process, in which it is well known that amalgam tended to adhere to the copper sides of the vessel unless the proportion of mercury to gold and silver present was less than four to one. Thus Baron Born wrote in 1786: § "In new kettles . . . the inside becomes wholly and so perfectly silvered that it never can be cleaned. . . . The silvery coat is daily increased by slow and gradual apposition, and the crusts of amalgama, accumulating on the bottom and sides of the vessels, become gradually so thick that on emptying them they often fall off by their own weight as silver plates, which, when dry, show the laminated texture of their daily augmentation."

The knowledge of this behavior of amalgam in the Cazo process must have been common to many who were engaged in exploiting the quartz veins of the West soon after their discovery, and the speedy application of this knowledge is exactly what might be expected from those sturdy pioneers. Nevertheless, the exact date and locality of the introduction of the copper plate remains a matter for conjecture.

The copper plates fixed on the battery in the early fifties were about four inches wide and as long as the mortar, and were placed one on the "feed" side and one on the discharge side just underneath the screens. It was soon found that the plates worked better from the start if mercury was rubbed on them before they were placed in position, and this has now been invariably done for many years. Crushed ore, stones, water, and amalgam are flung violently against the plates and the amalgam is retained in great part.

The scouring action of the pulp on the plates is, however, always great, and becomes more violent in proportion as the stamps are larger. These are now as much as 1,100 and even 1,250 lb. in weight in the Transvaal—an enormous mass when compared with the 750 lb. stamp of a few years ago and the 120 lb. stamp of the last century. With this increase in weight, it has become desirable to modify the use of the copper plate. The plate on the feed side, long ago condemned by many, is accordingly being discarded more and more, and that below the screens is curved away in such a manner that it cannot be struck directly by the splash from the stamp, while slots in cast steel plates lining the mortar have been devised for the purpose of catching amalgam.

After leaving the mortar the pulp was treated forty years ago mainly by passing it over inclined tables covered with blankets, much in the same way as Jason may have seen the golden sands worked in Asia Minor. The sands accumulating on the blankets were washed off at intervals and ground in mills with mercury. In addition, the orew as frequently passed over or through baths of mercury (as is still done in many Australian mills) and concentrated in various ways. Amalgamated copper plates over which the pulp flowed were tried, but in Western America were at first almost everywhere rejected,‖ probably owing to the great depth of the stream of ore and water made to flow over them. When this mistake began to be rectified, some twenty-

* Diodor., iii, 13. A full translation is given by B. H. Brough in his Cantor Lectures on Mine Surveying. Jour. Soc. Arts, 1892.

† Vit., lib. vii, cap. 8.

‡ Nat. Hist., lib. xxx, cap. vi, sect. 33. Quoted in full in Percy's Metallurgy of Silver and Gold, p. 559.

§ Salmon's Geber, cap. 47.

‖ Theophili, lib. iii, cap. 49.

¶ De la Pirotechnia. Venetia, 1540. Lib. ix, cap. xi, fol. 142.

* Agricola. De Re Metallica, p. 233. Basel, 1556.

† Agricola, loc. cit.

‡ Voyages Metallurgiques, vol. ii, p. 309. Paris, 1780.

§ Baron Inigo Born's New Process of Amalgamation, p. 122, translated by Raspe. London, 1791.

‖ See Nevada and California Processes of Silver and Gold Extraction, p. 61, by G. Kustel. San Francisco, 1863.

five years ago, the value of the plates was soon recognized in California.

In the extraction of gold from crushed ore by means of amalgamated copper plates, the pulp is led over their surface in a very thin stream, not more than a quarter of an inch deep. The plates are slightly inclined, wider than the screens from which the pulp issues, and from six to twelve feet long. The pulp does not run down in a regular stream, but in a series of little wavelets which tumble over and over and are supposed to bring every part of the pulp in succession in contact with the amalgamated surface. The catching powers of the plates are thus supposed to be practically independent of the tendency of the particles of gold or amalgam to sink to the bottom of the stream. This theory is not accepted by the Austrian school, and it is certain that native gold is caught more easily in proportion as it contains less silver, so that when the particles of metal consist of an alloy largely consisting of silver, and are therefore of comparatively low density, the yield on the plates is generally poor. In any case, however, the amalgamated plate should theoretically be better adapted for its work than the Tyrolean mill and other machines using mercury baths, owing to the slight depth of the pulp on the plates and the short distance through which the gold particles are compelled to settle before reaching a catching surface. The plates are wiped down with rubber or brushes about once a day and the gold separated in the usual way from the excess amalgam thus collected.

Admirable as is the amalgamation process in many respects, it has always been recognized that the extraction of gold by its use is generally far from complete. Besides the comparatively large particles of free gold which are readily saved by amalgamation, all ores contain more or less gold in an excessively fine state of division (the aurum larvatum or "disguised" gold of the last century) as well as gold contained in sulphides (aurum mineralisatum), and these particles cannot be extracted by the copper plates.

In an investigation on the dimensions of gold particles in ores J. A. Edman * observed a single chip of quartz $\frac{1}{20}$ inch in diameter, which when magnified 50 diameters, showed over 300 particles of gold varying in size from $\frac{1}{1000}$ to $\frac{1}{17000}$ inch, not only on the surface of the stone, but scattered though the transparent mass. Higher powers showed still greater numbers of smaller particles. The gold contained in pyrites, if, as seems likely, it is generally free, must be often still finer. It has been likened to the mortar in a brick wall, and is almost as difficult to catch as the motes in a sunbeam. Prolonged grinding with mercury no doubt increases the chances of such gold being amalgamated, and hence the success which has frequently attended the use of the Mexican arrastra, where the grinding surfaces are of stone, and of its successor the iron amalgamating pan.

Nevertheless, the yield of gold, mainly owing to the "flouring" and "sickening" of the mercury, is not always good even in these slow working and therefore costly machines. Mercury, when triturated with ore for a long time, tends to break up into very fine particles which, although apparently clean and bright under the microscope, refuse to run together, and are carried away by the stream of water and lost, together with the gold already taken up by them. Such mercury appears grayish white, and is said to be "floured." Moreover, when base metals are present in the ore they become amalgamated, and then, oxidizing, coat the surfaces of the globules of mercury with black scum, which effectually prevents the amalgam from adhering either to gold or to amalgamated plates. This "sickening" is doubtless also caused by the formation of compounds of the mercury itself. Ores containing sulphides of arsenic or antimony (which are reduced by mercury) are particularly apt to cause "sickening," but manganese dioxide, partly decomposed copper pyrites, zinc blende, and galena are also harmful.

It has been well known ever since the time of Agricola that the gold contained in these minerals, although not easy to extract by mercury, may be readily obtained by concentrating the ore (all finely divided free gold being, of course, lost in the process); the concentrates are then smelted, the gold accumulated in a reduced metal, such as lead or copper, and subsequently separated by cupellation or other means. The impossibility of applying this method of procedure to individual mines far distant from coal beds, and in places where a mixture of different kinds of ore cannot be obtained, prevents the universal application of the method, although in the neighborhood of such smelting centers as Freiberg and Denver nothing better is required.

The chlorination process, now nearly fifty years old, is of more general value for treating concentrates. Chlorine is a somewhat slow solvent for gold, any particle occurring native which is visible to the unassisted vision requiring many hours for its complete dissolution; but it is well adapted to dissolve the fine flakes existing in pyrites. Unfortunately, chlorine has a strongly preferential action on sulphides, and to avoid the enormous waste of gas which a small percentage of these substances cause it is necessary to precede chlorination by careful and complete roasting. After this there is little difficulty in the process. Oxides of the metals, except the alkaline earths, are very slowly attacked by chlorine; and when the alkaline earths are present salt is added in the roasting furnace. Chlorine is applied to the slightly damped ore in the form of gas, or, in more modern practice, as a strong aqueous solution. After a day or two the liquid is filtered off, and the gold precipitated by ferrous sulphate or sulphureted hydrogen.

The problem of the extraction of gold contained in pyrites and complex minerals was partially solved by the chlorination process, but the cost of roasting is a stumbling block in many cases, and it was the desirability of avoiding this which led to the introduction of the use of cyanide solutions for leaching, probably the most important event in the history of the metallurgy of gold since the first application of mercury to gold extraction. The extraordinary properties of very dilute solutions of cyanide of potassium were unmarked and in great part unknown until quite recently. That metallic gold is soluble in alkaline cyanides unaided by an electric current remained an interesting but useless fact until it was found that a solution containing only one per cent. of potassium cyanide dissolves gold at least as rapidly as much stronger solutions, although it has a very slow and partial action on most sulphides and other minerals occurring in gold ores. The presence of free oxygen is necessary for the dissolution of the gold, which takes place according to the equation

$$4Au + 8KCy + O_2 + 2H_2O = 4KAuCy_2 + 4KHO.$$

The oxygen is supplied from the air entangled in the porous ore, or dissolved in the solutions, in which MacLaurin * has shown that it can be retained in the presence of alkaline cyanides in spite of its rapid absorption by the latter with the formation of cyanates. The gold can be recovered by precipitation on zinc and subsequent melting, or by electrodeposition on suitable cathodes, of which lead only has been largely used.

The development of the cyanide process proceeded apace as soon as it had been introduced. The mechanical improvements devised were numerous, the most important being the enlargement of the size of the leaching vats, until the largest now hold 600 tons of ore. The chief chemical improvements have been the introduction of the use of caustic soda or lime to neutralize the acids and acid salts in "weathered" pyritic ores, and the reduction in the strength of solutions, the favorite "strong" solution now containing from 0·25 to 0·30 per cent. of available KCy, while solutions as weak as 0·01 per cent. are found in many cases to be equally efficacious if a somewhat longer time is allowed. In accordance with the experience in the extraction mills, MacLaurin † has found that gold and silver in the form of plates are most rapidly dissolved by solutions containing from 0·1 to 0·4 per cent. of cyanide, the maximum rate being observed with solutions containing about 0·25 per cent. of cyanide of potassium. A fairly rapid rate of dissolution, however, is still observable when only 0·005 per cent. of KCy is present.

Cyanide of potassium acts rapidly when free oxygen is present in large quantities, as for example when gold floats on the solution, with its upper side dry. Under such conditions, cyanide is at least as rapid in action as chlorine, but in proportion as the supply of free oxygen falls off, the rate of dissolution of gold in cyanide becomes slower, and when air is excluded as rigidly as possible, hardly any action can be observed. In practice, these facts are of importance. Finely divided gold in ordinary ores is dissolved in two or three days. When concentrates containing a large proportion of sulphides are being treated, however, free oxygen is absorbed by the pyrites as well as by the solution, and the treatment lasts as much as two or three weeks with a corresponding increase in the destruction of the cyanide by the minerals in the ore. An artificial supply of oxygen or of oxidizing agents shortens the time required but increases the waste of cyanide. Moreover, when pyritic ores or concentrates contain much marcasite, and, in many cases, when copper sulphides or some other minerals are present, the process is useless, enormous quantities of cyanide being converted into other compounds before any gold is dissolved.

The process is therefore of limited application to complex ores and concentrates generally, although of wide applicability to ores comparatively free from sulphides, especially after the coarser particles of gold have been removed by amalgamation. Certain deposits of complex ores, above the average in richness, are at present left untouched for want of a process by which they can be treated.

The cost of treatment of gold ores by the processes described above of course varies enormously with the locality and the special conditions of the case. Under favorable conditions the following may indicate approximately the minimum amount of gold which must be present in an ore, in order that it may be treated at a profit by the most suitable process. Auriferous sand, washed in the miner's pan, must contain about one part of gold in 100,000 or say six pennyweights per ton of ore. When the sluice is used, the sand being excavated and carried to the sluice by hand labor, as in Siberia, there must be at least one part of gold in 2,500,000 parts of sand, or six grains to the ton. When the hydraulic method is possible, only one part in 18,000,000 may be enough, or three-fourths of a grain of gold per ton, a proportion about equal to that which Liversedge ‡ found to exist in the sea water off the east coast of Australia. If the gold is contained in quartz, the cost of mining and of crushing the stuff makes the whole process of treatment far more expensive. Excluding the cost of mining, however, the cost of crushing and amalgamation requires the presence of at least one part of gold in 400,000, or say one and a half dwts. per ton. The cost of chlorination is equal to not less than one part of gold in 200,000 of ore or three dwts. per ton, although if only applied to concentrates, the cost per ton of the original ore may be trifling. Lastly, the cyanide process might be applied to the crushed tailings from the amalgamation process if they contain more than one part of gold in 600,000 or one dwt. per ton. If the ore has to be crushed, it must of course be richer. As stated above, these estimates apply only when the conditions are the most favorable. In general, such poor ores could not be worked at a profit.

At the present time the annual production of gold from all these sources is about £42,000,000 per annum, or double the output of seven years ago. It is greater than at any previous period in history, the nearest approach to it having been made in 1853, when the river gravels of California and Australia were at their best. The output was then estimated at £38,000,000.

Of the present output, washing processes, formerly instrumental in producing by far the larger proportion of the gold won, are now probably answerable for no more than 30 per cent. The amalgamation of crushed vein stuff, now the most important process, produces about 55 per cent. of the whole gold production. The two wet processes, chlorination and cyanide, account for some 11 per cent. of the output, of which about two-thirds are contributed by the cyanide process, and, lastly, smelting perhaps produces 3 or 4 per cent. of the total. In the future, as placer gravels become exhausted more and more, the proportion of the output derived from them will continue to fall off, and the greatest increases will certainly take place in the produce from stamp battery amalgamation and the cyanide process. The output from chlorination and from smelting has been for some years stationary or declining, and their proportion of the world's production will doubtless suffer a continued though gradual reduction. It is obvious that by new discoveries the whole direction and progress of the art might be modified. As the old deposits become exhausted the miner is compelled to go deeper into the earth and the metallurgist to treat poorer and more refractory ores. "Such is the vast labor expended on the extraction of gold. And from this description I think it is clear that gold is hard to get as it is difficult to keep; and though all men long to get it, yet when they have it they find as much pain as pleasure in the use of it."

* Mining and Scientific Press, San Francisco, August 12, 1882.

* Jour. Chem. Soc., vol. lxiii, p. 734 (1893).

† Jour. Chem. Soc., loc. cit. and vol. lxvii, p. 199, 1895.

‡ Proc. Roy. Soc. of N. S. W., 1895.

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